

STATE COLLEGE OF WASHINGTON
AGRICULTURAL EXPERIMENT STATION
Pullman, Washington

DIRECTOR'S OFFICE

Fortieth Annual Report
For the Fiscal Year Ended June 30, 1930

BULLETIN No. 245
December, 1930

All bulletins of this station are sent free to citizens of
the State on application to the Director

BOARD OF REGENTS

A. W. Davis, President	Spokane, Wash.
W. A. Ritz	Walla Walla, Wash.
F. J. Wilmer	Rosalia, Wash.
J. H. Hulbert	Mount Vernon, Wash.
Walter R. Rowe	Naches, Wash.
E. O. Holland	(President of the College, Secretary, ex-officio)

EXPERIMENT STATION STAFF

E. O. Holland, Ph.D., President	Edward C. Johnson, M. A., Director
Wm. C. Kruegel, B.A., Treasurer	

Agricultural Engineering

- L. J. Smith, M.E., Agricultural Engineer in Charge.
- H. L. Garver, E.E., Investigator, Farm Electricity.¹

Agronomy

- E. G. Schafer, M.S., Agronomist in Charge.
- E. F. Gaines, D.Sc., Cerealist.²
- A. L. Hafenrichter, Ph.D., Asst. in Farm Crops.
- S. C. Vandecaveye, Ph.D., Soil Biologist.
- H. F. Holtz, M.S., Associate in Soils.
- O. E. Barbee, M.S., Asst. in Farm Crops.
- H. P. Singleton, M.S., Associate in Agronomy, Irrigation Branch Station, Prosser.
- C. C. Wright, M.S.,³ Specialist in Irrigation Investigations, Irrigation Branch Station, Prosser.²
- Harley Jacquot, B.S., Asst. in Agronomy, Adams Branch Station, Lind.

Animal Husbandry

- Howard Hackedorn, B.S., Animal Husbandman in Charge.
- Jerry Sotola, M.S., Asst. Animal Husbandman.

Chemistry

- J. L. St. John, Ph.D., Chemist in Charge.
- J. R. Neller, Ph.D.,³ Associate Chemist.
- Otto Johnson, M.S., Assistant Chemist.

Dairy Husbandry

- E. V. Ellington, B.S., Dairy Husbandman in Charge.
- H. A. Bendixen, M.S., Associate Dairy Husbandman.
- L. A. Black, Ph.D.,³ Associate Dairy Bacteriologist.

- J. C. Knott, M.S., Superintendent Official Testing.

Entomology & Zoology

- R. L. Webster, Ph.D., Entomologist in Charge.
- Anthony Spuler, M.S., Assoc. Entomologist.
- Arthur J. Hansen, M. S., Assistant Entomologist, Western Washington Experiment Station, Puyallup.

Farm Management & Agricultural Economics

- Geo. Severance, B.S., Agric. Economist in Charge.
- E. F. Dummmeier, Ph.D., Agric. Economist.

- Chester C. Hampson, M.A., Assistant Agric. Economist.
- E. F. Landerhohn, M.S., Asst. in Farm Management.
- Harvey W. Starling, B.S., Asst. in Rural Sociology.

Home Economics

- Florence Harrison, A.M., Home Economist in Charge.
- Evelyn H. Roberts, M.S., Research Specialist in Home Economics.
- VeNona Swartz, M.S., Research Specialist in Foods and Nutrition.

Horticulture

- E. L. Overholser, Ph.D., Horticulturist in Charge.
- O. M. Morris, M.S., Horticulturist.
- C. L. Vincent, M.S., Asst. Horticulturist.
- F. L. Overley, M.S., Associate in Horticulture, Wenatchee.
- L. L. Claypool, B.S., Asst. Horticulturist, Irrigation Branch Station, Prosser.
- Max B. Hardy, M.S., Assistant.

Plant Pathology

- F. D. Heald, Ph.D., Plant Pathologist in Charge.
- L. K. Jones, Ph.D., Assoc. Plant Pathologist.
- H. H. Flor, Ph.D., Assoc. Pathologist.²

Poultry Husbandry

- John S. Carver, B.S., Poultry Husbandman in Charge.
- L. W. Cassel, B.S., Asst. Poultry Husbandman.

Veterinary Science

- J. W. Kalkus, D.V.S., Veterinarian in Charge, Western Wash. Exp. Station, Puyallup.
- C. E. Sawyer, D.V.S., Research Veterinarian, Western Wash. Exp. Station, Puyallup.

Branch Stations

- H. M. Wanser, M.S., Supt., Adams Branch Station, Lind.
- H. P. Singleton, M.S., Superintendent, Irrigation Branch Station, Prosser.
- D. J. Crowley, B.S., Specialist in Cranberry Investigations, Cranberry Investigations Laboratory, Long Beach.

¹In cooperation with the State Committee on the Relation of Electricity to Agriculture.

²In cooperation with the United States Department of Agriculture.

³Resigned.

LETTER OF TRANSMITTAL

State College of Washington
Pullman, Washington
December 2, 1930

His Excellency, Roland H. Hartley, Governor
Olympia, Washington

Sir:

In accordance with federal statute of March 2, 1887 and subsequent enactments, I have the honor to transmit herewith a report of the activities of the Washington Agricultural Experiment Station and branch stations for the fiscal year ended June 30, 1930.

For convenience some of the work is reported upon for the period November 1, 1929 to November 1, 1930. The context shows where this is the case. A financial statement of the receipts and disbursements for the last fiscal year, as prepared by the treasurer of the experiment station, is included.

Very respectfully,


DIRECTOR

FORTIETH ANNUAL REPORT

Washington Agricultural Experiment Station

DIRECTOR'S STATEMENT

Introduction

Because of the great diversity of the agriculture of Washington, the farming industry has problems of many kinds. In connection with the production and marketing of every crop from wheat to cranberries and of livestock from beef cattle to poultry difficulties of one kind or another are encountered, which the individual farmer, unaided, is unable to solve.

Not only are the problems numerous, but they are constantly changing, and new problems present themselves from year to year. Virus diseases of potatoes, which are now prevalent and do much damage unless disease-free seed is used, were not known when potatoes were first grown in the state. Weeds were not a problem until extensive farming had become general, but now they are one of the major problems of the state's agriculture. Such insects as the red spider on apples, the tarnished plant bug on pears, and the strawberry root weevil were not here when the crops they now infest were first grown in the state. Poultry diseases were not a serious problem until intensive commercial poultry production developed with consequent crowding of birds on small areas. As long as lettuce, asparagus, sweet potatoes, and other truck crops were not grown commercially, the use of cultural methods that produce a maximum crop of high quality at a minimum outlay was not essential, but now this is important if success with these enterprises is to be had. Less intensive spraying and less refined methods for insect control in orchards were necessary when the orchards were comparatively few or were just coming into bearing than today, because insect infestation then was less universal than now. Fertilizer problems were not thought of when soils were new, but now are assuming importance in the orchard sections, in the coastal area west of the Cascades, in the general farming sections in the irrigated country, and even in the wheat country

of eastern Washington. Less refinements in tillage practices were necessary with virgin soils than with soils where much of the humus and nitrogen has been removed by cropping for many years. As long as there was free land for grazing the family cows and commercial dairying had not developed, there was not much need to worry about pasture mixtures, pasture management, nor the proper feeding of concentrates, nor was there much need for emphasis on quality of butter, cheese, and ice cream. But all of these are problems today. Such crops as cranberries, blueberries, bulbs, and sweet potatoes are of comparatively recent introduction in the state, and each one has its own problems. It is clear, therefore, that as the agriculture of the state has developed, the agricultural production problems have increased in proportion. This process is still going on and as soon as one problem is solved, there is another and more often many others to take its place.

But this is still not all. The marketing of products grown is an immense undertaking. The greater part must be marketed outside of the state and at a great distance. Such matters as quality, pack, standards, transportation, storage, market organization, financing and credit are involved, and every step must function effectively if the producer is to have a proper return for his efforts. This gives rise to a whole field of new problems which are constantly changing with the development of commerce and industry and the progress of the state.

All this means that continued and increased effort in the matter of experimental and research work is needed from year to year to meet new situations if the different farming enterprises of the state and of the agricultural industry as a whole are to succeed. This is well realized in Washington, and much of the experimental and research work under way is watched with great interest by the leaders in the agricultural industries, and the results are applied in their work. As the value of these results is recognized, the desire for additional work to speed up that now under way and to take care of problems not now studied becomes more and more insistent. This has been particularly true in connection with the horticultural, poultry, pea, beet seed, and greenhouse growers industries during the past year. Leaders in these industries have visited the State College or called upon representatives of the institution in the field, urging that much new or additional experimental and research work be undertaken. From time to time as one problem is completed, a new problem is undertaken. In other instances a shift from one problem to another may be made, but usually this is not possible without serious interruption or discontinuance of work only partly finished and with much loss to the entire program because of leaving problems unsolved on which much time and funds already have been expended.

The realization of the practical value of experiment station work is well illustrated by the support given to the orchard investigations in the Wenatchee area. For eleven consecutive years Chelan County, through its Board of County Commissioners, has contributed generously from county funds for this project. Further, these funds have been reinforced by contributions from the Wenatchee Valley Traffic Association. Spray manufacturers have contributed for assistance on special problems in this area. The Northwest Fertilizer Association has furnished funds for important studies of the value of fertilizers for orchard crops. Through this support supplementing the work of members of the staff of the experiment station, at present located at Wenatchee, it has been possible to conduct an effective research program over a period of years on sprays and spray practices, fertilizers, spray residue removal, fruit development and orchard management which have been of immense value to the fruit grower.

Because of this exceptional support in the Wenatchee area the conclusion might be drawn that the best way to provide for experimental work is by means of contribution from the agricultural industry itself and from the specific areas in which the work is located. This has certain advantages and many disadvantages. Its advantages are a keen local interest in the work done and the rapid application of the results obtained because of that interest. Its disadvantages are that, while local support and the support of commercial agencies may be secured from time to time, usually it is obtained for specific short-time problems only from which positive results may be expected in a brief period, and it may be discontinued at any time before projects under way have been completed. This has been the experience twice this year in connection with important studies supported in part by private agencies. Long-time fundamental research, therefore, cannot be carried on in this manner. Experiment station research must be able to solve many fundamental long-time problems, and this involves dependable support from year to year. Moreover, there is such a large variety of crops and livestock and of farming conditions, and the number of farmers is so great and have such a diversity of interests that their organization for financial support of the experimental and research work necessary, except as it may deal with special local short-time problems, becomes impractical and well-nigh impossible. It is for these reasons that public support through appropriations by the states and the federal government for experimental and research work in agriculture is necessary.

Moreover, experimental and research work in agriculture, while of direct benefit to the agricultural industry and to the farmer, is not for the benefit of the farmer alone. It contributes greatly to the welfare of all the people. The non-agricultural population often profits as much and more than the farmer from the application of

sound practices to agriculture, since in this way abundant food supplies of good quality, and ample materials for clothing are insured. In addition, the soil resources are conserved for present and future generations. It is logical, therefore, that the state and the nation should be interested in agricultural research and give generous support from public funds. This point has been discussed in considerable detail by the Office of Education of the United States Department of the Interior in a recent report of a nation-wide survey of the work of the Land Grant Colleges and Universities, of which the following is an extract.*

"Question is sometimes raised as to the reasons for public financing of agricultural research. The history of the establishment of the United States Department of Agriculture and of the State stations indicates that the welfare of agriculture was looked upon as basic to the welfare of the Nation and all its people. There was nation-wide concern about agriculture following the Civil War. Agricultural research, through the State stations and the Department of Agriculture, were a part of the national and State welfare as well as welfare of the farm population. The 37 institutions reporting agree that the welfare of agriculture still is of sufficient importance to the welfare of all classes of people to constitute a major basic reason for public financing of agricultural research. The reason is given first place by 29 of the 37.

"The interest of the public in promoting unrestricted use of the findings of research which may reduce cost of production and distribution, improve quality, and insure supply of agricultural products is ranked equal in importance to agricultural welfare by 6 of 32 states reporting. At a time of agricultural surpluses this reason for public support assumes less importance in the minds of many than it should. It is an essential element of the constant problem of placing agriculture on a parity with other industries, and yet maintain food supply, in quantity and quality, at a price consistent with the purchasing power of consumers.

"The difficulty of organizing agriculture for self-supporting research is a third important reason for public financing of agricultural research. Agriculture is made up of many enterprises and activities engaged in by large numbers of individuals operating under wide diversity of conditions. The problem of self-financing for agricultural research is made more difficult by the fact that findings from agricultural research are so difficult to control through patent or otherwise. A new crop, a new cultural method, new herd management, can not be monopolized and any agency other than the public would have difficulty in securing financial returns on the discovery sufficient

* Survey of Land Grant Colleges and Universities. Office of Education Bulletin No. 9, 1930. Vol. 2, pp. 611-612.

to encourage further research. The public gets its return through decreased cost of living and from the increased purchasing power of agriculture.

"These reasons for public financing of research in agriculture are of considerable weight in justification of the wisdom of present national and State policies."

Investigations in Cooperation with the United States Department of Agriculture and other Agencies

Notable progress has been made during the year among the experiment stations of the Pacific Northwest on problems that are regional in character and lend themselves to joint investigation, and in cooperation between the United States Department of Agriculture and the various stations. In cooperation with the University of Idaho and the United States Department of Agriculture a study was made of systems of farming in eastern Washington and in northern Idaho, embracing the area where rainfall is in excess of 18 inches. On the basis of field studies of the work and experience of some of the best farmers of the region, and on results of experimental work for many years by the Washington and Idaho stations, the types of farming adapted to the area were definitely outlined and budgeted so that every farmer may use these setups as a guide in his own operations.

The matter of handling grain in bulk and to what extent bulk handling should become a practice in the Pacific Northwest is a subject of cooperative study between the Idaho, Oregon and Washington Experiment Stations and the United States Department of Agriculture. This study is now under way and will be completed in 1931.

On recommendation from a tri-state grain growers' conference, held at Pullman in 1928, to the United States Department of Agriculture and to the U. S. Congress, the appropriation to the Office of Cereal Crops and Diseases was increased to enlarge the cereal improvement work in the Pacific Northwest. A conference of representatives of the Oregon, Idaho and Washington Experiment Stations was called by that office at Walla Walla in June 1930 for a consideration of the program to be undertaken. Definite plans were initiated for correlating and expanding the cereal improvement work of the three states and the United States Department of Agriculture. Special attention will be given to the smut problem which has become more complicated in recent years, because of a number of virulent smut strains that have developed or have come into the Inland Empire wheat producing area from the outside.

Soil erosion has become a serious problem in large areas of the United States, so that much land has been destroyed and made of no value for farming purposes. This is particularly true in some of the

older farming sections in the east and south, but the ravages of erosion also have become noticeable in the middle west and in the Pacific Northwest. This problem was presented to the Congress of the United States by the Bureau of Chemistry and Soils in 1928, and a policy was adopted of making federal appropriations to establish regional experiment stations in the more important soil areas of the country to find the best means of preventing or controlling soil erosion. Application was made by this state for the establishment of one of these soil erosion stations in the Pacific Northwest. This was supported by adjoining states and in the spring of 1930 the Congress made an appropriation for this purpose. Representatives of the Bureau of Chemistry and Soils and the Bureau of Public Roads of the U. S. Department of Agriculture came to the Pacific Northwest during the summer of 1930 to select a site for the station which would be thoroughly representative of the soil area to be served. After detailed inspection of much of the Inland Empire a 200-acre farm, three miles from Pullman, was decided upon as being most suitable for the purpose. Since the federal appropriations could not be used for the purchase of land, the State College of Washington was asked to find ways and means of securing this farm. The matter was presented to citizens of Pullman and the surrounding farming community who expressed unanimous approval of the project and their desire to cooperate in every way possible. Arrangements finally were made for the Community Building Company of Pullman, a local organization, to purchase the land and to rent it to the State College for a period of years for use in the cooperative study on the prevention and control of soil erosion. The land has been rented by the State College from the Community Building Company, funds for the operation of the station will be provided by the federal government, offices and laboratories for the representatives of the U. S. Department of Agriculture will be furnished by the State College, and the receipts from crops produced as a by-product of the experimental work, will be credited to a special fund to be used in helping to take care of the rental. In addition, pledges have been signed by more than 50 business men and farmers of the Pullman community and eastern Washington to contribute not more than \$20.00 a year apiece for five years to help take care of the rental in the event receipts from the land will not be ample for the purpose. Within a period of 16 years the land will become the property of the State College.

The new station is just one mile from the Inland Empire Highway, and Whitman County, through members of the Board of County Commissioners, has pledged itself to build a surfaced road from the Inland Empire Highway to the station so that it can be reached any time of the year for experimental work and for inspection by those interested in the prevention of soil erosion.

The work at the soil erosion station will be planned from year to year by the representatives of the U. S. Department of Agriculture and of the Washington Agricultural Experiment Station in cooperation, and with the advice of an advisory committee representing the experiment stations and the farmers of Oregon, Idaho and Washington.

The Office of Cereal Crops and Diseases of the U. S. Department of Agriculture has been cooperating in the development of smut resisting and superior varieties of cereals for several years and as already indicated in this report, has enlarged this cooperative undertaking during the current year. The Office of Forage Crop Investigations of the same department has cooperated with the station for 12 or 13 years in a study of forage crops for Washington, and is continuing its cooperation.

At the Irrigation Branch Station at Prosser, a representative of the U. S. Department of Agriculture who devotes his entire time to a study of irrigation problems is maintained by the Office of Western Irrigation Agriculture. This makes possible a program of fundamental studies in irrigation agriculture of benefit to the major part of irrigated Washington.

The Bureau of Agricultural Economics of the U. S. Department of Agriculture in addition to cooperating in a study of farm set-ups in eastern Washington, has cooperated in a study of community organization in selected communities in the state of Washington. The Bureau of Animal Industry of the same department has continued its cooperative work in the studies of the rate of wool growth on sheep.

Additional contributions to our knowledge of the use of electricity on the farm have been made possible by the continued support of the Washington State Committee on the Relation of Electricity to Agriculture. The funds for this work have been supplied by members of the committee.

Unofficial cooperation between the fruit laboratories and the codling moth laboratories of the U. S. Department of Agriculture, located at Wenatchee and Yakima respectively, and representatives of the agricultural experiment station who are devoting their time to orchard problems, have been very helpful.

In cooperation with the State Department of Agriculture and the Bureau of Entomology of the U. S. Department of Agriculture, directions for orchard spraying in Washington for the 1930 season were prepared and distributed. This was the fourth year of joint recommendations of these three agencies. In all four years the directions have been given general distribution to all fruit growers of Washington by the press, the Extension Service and the State Department of Agriculture.

The Main Experiment Station and the Western Washington Experiment Station have a number of cooperative projects in berries, in poultry, insects injurious to western Washington crops, and diseases of livestock, and have inaugurated additional cooperative investigations in pastures and dairy cattle management.

A number of investigations such as the study of apple prices and the marketing of apples, and the home economics projects of the experiment station are conducted as a part of national projects in which several experiment stations and the U. S. Department of Agriculture actively cooperate.

The Colloidal Products Corporation of San Francisco, California, the Kay Laboratories, Inc., of West Haverstraw, New York, and the Crop Protection Institute, with headquarters at Durham, New Hampshire, have cooperated in studies of the use of certain spray materials in insect control. The larger part of this work has been done in the Wenatchee area.

The Washington Experiment Station and the experiment stations of Idaho, Oregon, Montana, California and British Columbia and the U. S. Department of Agriculture, through conferences between entomologists, chemists, horticulturists and plant pathologists and by interchange of information and materials, have continued the cooperative studies commenced four years ago in the use of oil sprays for insect control.

The Northwest Fertilizer Association with headquarters in Seattle, for the third successive year has cooperated in the study of fertilizers for orchards.

The Chilean Nitrate of Soda Corporation of New York City has cooperated in a study of the use of nitrate of soda and other fertilizers for field crops and pastures.

Much assistance has been given by county agents and Smith-Hughes teachers in experimental work with crops, soils and fertilizers in the more important crop areas of the state.

Investigations in Horticulture in Cooperation with Chelan County

As indicated elsewhere in this report, for the eleventh consecutive year, Chelan County, through action of its Board of County Commissioners, has cooperated actively in investigations in horticulture, and the control of horticultural insects in the fruit section of Chelan County. Sufficient funds have been appropriated to cover the maintenance expenses of an horticulturist and an entomologist who have spent the entire year in experimental work in the Wenatchee district.

Changes in Staff

Dr. J. R. Magness, Professor of Horticulture, resigned September 1, 1929.

Miss VeNona W. Swartz was appointed Research Specialist in Foods and Nutrition, September 16, 1929.

Miss Catherine Landreth, Research Specialist in Nutrition, resigned November 15, 1929.

Mr. E. L. Green, Assistant Chemist, resigned December 29, 1929.

Mr. Harry Jensen, Assistant Horticulturist at the Irrigation Branch Experiment Station, resigned January 1, 1930.

Dr. E. L. Overholser was appointed Professor of Horticulture and Head of the Department of Horticulture, February 1, 1930.

Mrs. H. H. Flor was appointed Assistant in the Division of Chemistry for a temporary period, January 20 to June 1, 1930.

Mr. L. L. Claypool was appointed Assistant in Horticulture at the Irrigation Branch Experiment Station, February 1, 1930.

Mr. Otto Johnson was appointed Assistant Chemist in the Division of Chemistry, February 15, 1930.

Mr. Hector McDonald, Assistant in Animal Husbandry, resigned May 1, 1930.

Mr. Neil Johnson, Instructor in Farm Management, resigned June 1, 1930.

Mr. E. F. Landerholm was appointed Instructor in Farm Management and Assistant Agricultural Economist, June 1, 1930.

Mr. Harley Jacquot was appointed Assistant in Agronomy, Adams Branch Station, June 10, 1930.

Buildings and Land

A new dairy barn, modern in every respect and sufficiently large to care for the dairy herds at the State College of Washington was constructed during the fiscal year July 1, 1929 to June 30, 1930.

Detailed Reports

A brief statement of the work of each division of the Washington Agricultural Experiment Station and of each Branch Station for 1929-30 prepared by division and branch station heads and assistants is found in the succeeding pages of this report.

Lists of papers published in scientific journals and of station bulletins for the fiscal year also are included.

DIVISION OF AGRICULTURAL ENGINEERING

L. J. Smith in Charge

Soil Heating. (H. L. Garver). A study of soil heating for vegetables by means of electricity was undertaken with special reference to the possibilities of stimulating growth of certain garden vegetables for the early spring market. Different kinds of soil containing various percentages of moisture and organic matter are being used in these tests and the speed with which the heat travels through the soil and the direction determined.

All-Night Lighting of Laying Hens. (H. L. Garver in cooperation with the Division of Poultry Husbandry). The effect of all-night lighting of laying hens is studied. The lights used are so small that they do not discourage the birds from going onto their roosts, but give sufficient light to enable the hens to fly down for feed or water any time during the night. Should this method of lighting the laying hens prove satisfactory, it will eliminate the necessity of putting in the control equipment on the lighting system which is necessary when lights must be turned on evening and morning and when dim light must be used to force the birds to roost.

Pneumatic Elevation of Grain. (H. L. Garver). Considerable data were secured on elevating grain with a blower type of elevator. Grain on various farms was elevated at the rate of 250 to 380 bushels per hour. In one case this was done with a three and in another, with a five H.P. electric motor. The percentages of grain cracked in passing through the elevator were observed and a comparison in power requirements made between the blower and drag types of elevators.

The Use of Electrical Equipment in the Farm Home. (The Divisions of Agricultural Engineering and Home Economics have been cooperating in this study). Ranges, percolators, washing machines, and other electrical appliances are being studied under farm home conditions. Some equipment for these studies was lent to the farmers by the Committee on the Relation of Electricity to Agriculture.

Tractor Hitches. (C. C. Johnson). Studies of tractor hitches for the hilly Palouse country are being continued and one hitch has been designed and constructed.

DIVISION OF AGRONOMY

E. G. Schafer in Charge

Varietal and Cultural Investigations. (O. E. Barbce). Eleven introductions of winter wheats and 171 varieties carried over from the previous year were grown in the nursery trials in triplicate row

rows, and 49 inferior strains were discarded. Due to unfavorable conditions the yields secured from all varieties grown in the nursery were less than for the average of previous years. Two strains, Turkey number 2546 and a cross of Jenkin x Ridit showed sufficient merit to be placed in the field plot trials for 1931.

For the spring wheats, 38 new varieties were tested for the first time in the cereal nursery along with 147 other selections and strains. Forty-two varieties previously grown were discarded. All the hybrid crosses of spring wheats on winter varieties yielded less than their spring parent. Of the 26 new introductions from Russia Graecum number 10244 was outstanding in yield.

Twenty-nine varieties of oats were grown in the nursery for the first time along with 96 varieties grown the previous year. Of this group, two strains, Markton and a cross of Banner x Markton, excelled the others in yield producing 60.6 and 60.2 bushels per acre respectively.

Of the hulless hybrids and selections Large Hulless x Markton was at the head of the list in production with 33.3 bushels per acre. This equalled the yield secured from some of the hulled varieties.

Eight introductions of barley were included in the test this year along with 34 grown the previous year. The two-rowed varieties produced a smaller yield than the six-rowed varieties.

Eleven varieties of flax were grown in triplicate rod-rows, Chipewa ranking first in production with 9.3 bushels per acre and Red Wing second with 8.7 bushels.

All the varieties grown under field conditions in fortieth-acre plots were replicated four times, two following summer-fallow and two following peas. The average of all the varieties of winter wheat after summer-fallow was ten bushels more than the average of all the spring wheats after summer-fallow. However, spring wheats following peas yielded 2.3 bushels per acre more than winter wheat following peas.

Varietal trials were conducted in eight counties, and the leading commercial varieties of each locality were compared with leading varieties of other localities. This work was done in cooperation with the Extension Service through the county agents.

Distribution of Seed. (E. G. Schafer). Although farmers who have obtained pure seed from this station in previous years are distributing seed to other farmers, the demand for pure seed of the more promising varieties of wheat, barley, oats, and corn continues. Due to a shortage in supply, it was necessary to refer some parties desiring seed to farmers who had formerly obtained seed from this station.

Five hundred seventy-one bushels of Redit and 375 bushels of Albit wheat were distributed to 24 farmers during the year. Ninety-eight bushels of Beldi Giant Barley were distributed to seven farmers. Orders for 133 bushels of Alaska Peas were received from 13 farmers. Six hundred fifty-nine bushels of Markton Oats were supplied to 23 farmers. Windus White and Thayer Yellow corn together, which were supplied to 19 farmers, amounted to 840 pounds. A total of 100 farmers were served as compared to 118 in 1929.

Small samples of many varieties, ranging from a few ounces to a few pounds in size, were sent to twenty-six different stations and organizations interested in experimental work. At the request of the officials of the International Grain and Hay Show at Chicago, samples of superior varieties of wheat and oats developed at the Experiment Station were placed on exhibit at that exposition. Many samples were sent to Canada, various countries of Europe, and other parts of the world.

Physiologic Forms of Bunt. (E. F. Gaines, H. H. Flor, and W. K. Smith, in cooperation with the Divisions of Agronomy and Plant Pathology and the Office of Cereal Crops and Diseases, U. S. Department of Agriculture). Studies on the distribution and virulence of physiologic forms of bunt present in the state were extended in 1930. Forty varieties of winter wheat were inoculated with forms which have been used in tests since 1928, and the presence of five forms was shown. This was confirmed by similar tests on 34 varieties of spring wheat. High resistance to these forms was seen in a recent Turkey selection, Redit, Oro, Crimean number 2670, two strains of Hohenheimer, a selection of Jenkin x Redit, two of Turkey x Florence, and one of Hussar x Selection C. The most resistant spring wheats were Hope, Garnet, Siberian, Reliance and a Baart x Redit selection.

Inoculation of 10 winter wheats by bunt collections made in 1929 showed the presence of new forms.

Inheritance Studies in Cereals. (F. F. Gaines and W. K. Smith). Because of the increasing menace from new forms of bunt, many hybrids were tested. From this material 235 white seeded and resistant selections of the second generation, and 72 promising selections in the third generation will be available for test in 1931.

Hope, a spring wheat, has been highly resistant to all forms of bunt when spring sown. A detailed study was made of the inheritance of resistance in the third generation of a cross between this variety and Jenkin when different forms of bunt were used as inoculum. It was found that the factors in Hope which are responsible for the resistance to one form are the same as those responsible for the resistance to the other forms tested. On this account, Hope should be a valuable

parent in the production of highly resistant and desirable spring wheats. A study also was made of the inheritance of resistance to a virulent form of *T. levis* in crosses between Hope and four winter wheats.

Data have been taken on glume color, awns and habit of growth so that the relationship between these characters and bunt resistance may be determined.

Eleven oat smut collections, made in different parts of the state in 1929, were tested on seven differential varieties of oats. Differences in reaction produced by the collections were not sufficiently great to determine the number of forms present. Markton was immune from all collections.

From crosses between Markton and hulless varieties there have now been obtained seven fourth generation and 16 fifth generation selections which are hulless and immune from covered smut.

Crop Rotation. (E. G. Schafer). It has been found that the yield of winter wheat after summer-fallow is approximately the same whether preceded by one, two, or three successive crops of wheat. The yield of spring wheat has varied but little in the continuous spring wheat plots and in rotations of winter wheat, spring wheat and summer-fallow, or winter wheat, spring wheat two years and summer-fallow.

Weed Eradication Studies. (E. G. Schafer, J. R. Neller and A. L. Halenrichter). The experiments on the amounts of commercial herbicides required for eradication of the bindweed and Canada thistle were greatly expanded. The work was extended to other parts of the state and to several additional species of weeds. The residual and differential toxicity of the chlorates on various cereal and forage crops was determined for former sprayings and the study extended to plots sprayed in 1929. Control studies were made in the greenhouse. Under certain conditions spring wheat gives a fair yield on plots sprayed in the fall of the year preceding planting.

Studies of plant metabolism were continued, and soil tests were begun to determine whether lethal action of the chlorates was through the plant or through the medium of the soil. Especially designed critical strength of solution and critical environmental conditions were used to augment this study.

A series of tests to determine critical lethal applications of sodium chlorate and Atlacide indicate that these two chemicals are not equivalent as herbicides except under very limited conditions.

Work was continued on economic and practical methods of reducing the fire hazard when chlorates are used.

The increasing demand for effective methods of weed eradication, under climatic and soil conditions in various parts of the state necessitates the extension of this work.

Competition Between Forage and Grain Crops. (A. L. Hafenrichter, in cooperation with the Office of Forage Crops, U. S. Department of Agriculture). Field plots are being used to study the nature and degree of competition between sweet clover and alfalfa as forage crops when grown with cereals and grasses as companion crops. Several variations are used in the method of handling the companion crops. Ecological measurements of the forage crop population and of representative plants in the various plots indicate a greater degree of competition between winter grains and the forage crops than is evident for spring grains, grasses or peas. The results are influenced by cultural practices. Studies on competition are also conducted in the greenhouse under controlled conditions.

Sweet Clover Investigations. (A. L. Hafenrichter, in cooperation with the Office of Forage Crops, U. S. Department of Agriculture). Species, varieties, and strains of sweet clover are being tested in the nursery to determine their suitability for hay, pasture, green manure and breeding purposes. The response of selected strains to controlled conditions in the greenhouse is being correlated with field behavior. Promising hay-producing varieties and strains are grown in replicated row rows for determination of comparative yield, leafiness, and composition.

Time and method of seeding trials are in progress with unhulled and hulled biennial white clover. The data at hand seem to indicate the possibility of establishing a method which will give satisfactory results with fall seeding.

Greenhouse cultures and field plots are being used to determine the relationship of cultural practices and environmental conditions to the decomposition of sweet clover when used as a green manure crop.

The Maintenance of Organic Matter in Eastern Washington Soils. (S. C. Vandecaveye and H. F. Holtz). Since it has been found in the past that nitrogen is a controlling factor in the maintenance of soil organic matter and wheat yields in eastern Washington, the series of field plots established to study the relative value of inorganic and organic nitrogen fertilizers in this connection has given some interesting results. Yields from the plots where organic nitrogen has been applied in the form of alfalfa hay or barnyard manure have been less per unit of nitrogen supplied than those of the plots where equal amounts of nitrogen have been applied in the form of sodium nitrate or ammonium sulfate. Where straw alone has been applied at the rate of one and one-half tons per acre, yields have been less than those

of the unfertilized check plots while on all other plots yields have been greater than on the check plots. While greatest yields have been obtained from plots treated with inorganic nitrogen fertilizers, the most satisfactory nitrogen and soil organic matter maintenance has been obtained in the plots treated with organic nitrogen fertilizers and with the combination of ammonium sulfate and straw.

Intensive studies regarding the activities of various groups of soil micro-organisms during progressive stages of organic matter decomposition have shown that, during certain stages of decomposition, large quantities of atmospheric nitrogen may be fixed in a relatively short time by non-symbiotic nitrogen fixing bacteria.

Fertility Investigations of Washington Soils. (H. F. Holtz and S. C. Vandecaveye). The fertilizer plot work in the state in cooperation with county agents and Smith-Hughes teachers was continued this year and distributed as follows: West of the Cascade Mountains, 70 sets of plots were placed on 25 soil series, and east of the mountains, 30 sets of plots were placed in the irrigated and semi-humid districts. The results this season are similar to those of last year, nitrogen and phosphorous giving the greatest increases in yields.

For two years nitrogen fertilizer experiments have been conducted on hill-tops on farms throughout the wheat section of eastern Washington. The purpose of this work is to ascertain the possible variation in regard to fertilizer response in the different localities and also to determine the most desirable rate of application. Three rates of application, namely, 150, 250, and 350 pounds of sodium nitrate, or its equivalent per acre, were used. During the season of 1929 the 150 and 250 pound applications gave an increase of an average of 4.9 bushels of wheat per 100 pounds of sodium nitrate; during the 1930 season all three rates gave an average of five bushels increase per 100 pounds of sodium nitrate applied.

Plant Composition as Influenced by Variations in Soil Types. (H. F. Holtz and S. C. Vandecaveye). This project deals principally with changes that are brought about in the mineral content of various crops due both to the application of commercial fertilizers to various soils and to variations in climatic factors.

Results thus far show that a substantial increase in the mineral nutrient content of various crops may be procured on many soil series by the addition of commercial fertilizers.

The Management of the Irrigated Soils and the Utilization of Irrigation Water and Its Influence on Soil Composition. The management of the Irrigated Soils, and the Utilization of Irrigation Water

and its Influence on Soil Composition are projects conducted in co-operation with the Irrigation Branch Station at Prosser. The details of these projects are given on page 63.

Changes Occurring in the Irrigated Soils as a Result of Irrigation, Cropping, and of Fertilizer Treatments. (S. C. Vandecaveye and H. F. Holtz). This project was continued in the Wenatchee and Spokane irrigated orchard districts along much the same lines as reported a year ago.

In one of the orchards in the Spokane area where the various fertilizers have been applied for four consecutive years, there are definite indications that the pH of the soil is decreasing in all plots receiving nitrogen in the form of ammonium sulfate. The plots receiving phosphorous or potash in combination with nitrogen, or phosphorous and potash in combination with nitrogen in this same orchard yield more exchangeable calcium, magnesium, and potassium as determined by the electrodialysis and neutral salt solution methods.

The Effect of Various Factors on Inoculation and Nitrogen Fixation. (S. C. Vandecaveye). Although the results from repeated studies of the adaptability of various strains of alfalfa legume bacteria to western Washington soils have shown marked differences in the ability of nodulation of the various strains of alfalfa legume bacteria, satisfactory growth of alfalfa in its second year on certain soil types was not obtained with any of these strains of bacteria. The addition of lime to these soil types stimulated nodulation on the roots of the young alfalfa plant but failed to show its effect on the alfalfa in its second year's growth. The same may be said for the application of moderately heavy amounts of phosphorous and potash fertilizers applied separately or in combinations. These soils are not excessively acid and are well drained. The results seem to indicate that a satisfactory soil reaction, good drainage, the presence of lime, and an abundance of nodules on the roots are not the only requirements for successful growth of alfalfa on certain soil types. More detailed discussion and the completed data of this project are now being prepared for publication.

Distribution of Nodule Bacteria Cultures. (S. C. Vandecaveye and E. G. Schafer). This year, as in previous years, bacteria cultures for legume seed inoculation were distributed to the farmers of the state. Cultures were sent to 677 individuals. The total amount of inoculation material distributed was sufficient for legume seed for 12,107 acres. The acreage of the inoculation for the different legumes was as follows: Alfalfa, 2001 acres; sweet clover, 819 acres; red, white, and alsike clover, 208 acres; peas, 8851 acres; vetch, 211 acres and beans, 15 acres.

DIVISION OF ANIMAL HUSBANDRY

H. Hackedorn in Charge

Studies of Wool Growth. (H. Hackedorn and J. Sotola, in cooperation with the Bureau of Animal Industry, U. S. Department of Agriculture). Fifth year data on the rate of wool growth in Rambouillet sheep have been collected. A comparison of wethers shorn regularly with those carrying five-year fleeces shows a slightly smaller total wool growth for the unshorn wethers. The shorn and unshorn wethers show a gradually decreasing rate of wool growth each year. One of the unshorn wethers died, and the fleece removed totaled a weight of 76 pounds, with a staple $13\frac{1}{2}$ inches in length. The work with ewes has been abandoned.

The Biological Value of the Proteins of Alfalfa Leaves and Stems, and the Digestion Coefficients of Nutrients in Stems and Leaves. (J. Sotola). The hay used in this study was grown at the Irrigation Branch Station, Prosser, Washington. It was first cutting hay, of the variety known as Northern Grown Common. The leaves and blossoms, and finer portions of the petioles were separated by hand. The rations, in order of feeding, were as follows: (a) nearly nitrogen free rations, (b) alfalfa stems, (c) whole alfalfa hay, (d) alfalfa leaves, (e) nearly nitrogen free rations.

The alfalfa studied contained 50.27 per cent leaves and 49.73 per cent stems. The composition of the whole alfalfa was as follows: 12.19 per cent moisture; 11.67 per cent protein; 6.25 per cent ash; 1.42 per cent ether extract; 33.70 per cent crude fiber; and 34.77 per cent nitrogen free extract. The alfalfa leaves and blossoms from the same sample of hay contained the following composition: water, 13.43 per cent; crude protein, 17.61 per cent; ash, 8.98 per cent; crude fat, 2.42 per cent; crude fiber, 17.32 per cent; and nitrogen free extract, 40.24 per cent. The alfalfa stems were lower in nutritive value, with the following composition: water, 11.84 per cent; protein, 8.41 per cent; ash, 4.73 per cent; crude fat, 1.03 per cent; crude fiber, 41.34 per cent; nitrogen free extract, 32.65 per cent.

Digestibility studies with the whole alfalfa show that the dry matter in the hay is 52.8 per cent digestible, the crude protein 65.2 per cent; the crude fiber, 43.3 per cent; the nitrogen free extract, 65.0 per cent; and the fat, 14.4 per cent. In contrast with this are the higher coefficients of digestibility for the alfalfa leaves, which are 61.3 per cent, for the dry matter; 74.8 per cent for the crude protein; 55.5 per cent, for the fiber; 71.8 per cent, for the nitrogen free extract; and 16 per cent for the fat. The stems have a somewhat lower digestibility, with figures as follows: dry matter, 44.3 per cent; crude protein, 50.7 per cent; fiber, 35.2 per cent; nitrogen free extract, 55.8 per cent; and fat, 58.3 per cent.

The nutritive ratio for the whole hay is 1 to 4.95. For the leaves it is 1 to 2.99, and for the stems, 1 to 8.00. Applying the coefficients of digestibility, the results show that the whole alfalfa contains 45.25 pounds total of digestible nutrients; the leaves, 52.25; and the stems, 38.38 per hundred pounds of feed. The digestible protein per 100 pounds of each of these portions of hay is also of interest. The stems contain 4.26 per cent, and the leaves 13.17 per cent, while the whole hay contains 7.61 per cent.

Computations of the biological value of the various proteins show no differences for the proteins in the leaves and the whole hay, while the values are somewhat higher for the proteins in the stems.

The Study of the Nutritive Value of Apple Pomace. (J. Sotola). Apple pomace, a by-product of vinegar manufacture, was fed to sheep in metabolism crates, and its digestibility determined. The dry matter of this feed was 46 per cent digestible; the crude fiber, 47 per cent; and ordinary nitrogen free extract, 62 per cent. The feed itself is so low in nitrogen that the fecal nitrogen in almost every case exceeded the nitrogen intake. Practically every animal fed was in negative nitrogen equilibrium.

The composition of the apple pomace was as follows: water, 73.69 per cent; crude protein, .114 per cent; fiber, 4.23 per cent; nitrogen free extract, 20.41 per cent; ether extract, .825 per cent; and ash, .735 per cent. The seeds separated from several pounds of apple pomace were studied chemically and were found to have the following composition: 59.50 per cent moisture; 7.01 per cent crude protein; 7.11 per cent crude fiber; 15.42 per cent nitrogen free extract; 9.81 per cent ether extract; and 1.159 per cent ash. The excellent protein and fat content of the apple seeds is quite striking. There was approximately two per cent apple seeds by weight in the apple pomace studied.

The Effect of Plant Maturity on the Biological Value of Alfalfa Proteins. (J. Sotola). A new series of experiments has just been completed in which additional data have been secured on the effect of plant maturity on the biological value of alfalfa proteins. In these studies, alfalfa plants 12 inches high and those in half bloom and those in full bloom were studied to supplement the data previously secured with plants at the one-fourth, one-half, and three-fourths to full bloom stages. This year's studies again failed to demonstrate any differences in the biological values of the proteins in the plants of varying stages of maturity.

The Nutritive Value of Range Grasses. (Ralph McCall, H. Hackedorf, and E. H. Steffen). A new project, started in the fall of 1930, is designed to determine the nutritive value of the commoner range grasses when fed to sheep.

DIVISION OF CHEMISTRY

J. L. St. John in Charge

Characteristics of Maturing Apples. (J. L. St. John and J. R. Neller). The results of work previously done were published by St. John and Morris in the *Journal of Agricultural Research* 39:623. The extent of variation between duplicate samples is shown. The grade and position of the apples on the tree are important in sampling. The percentage of sugars and other constituents varies from year to year. Sucrose increases during the growing season. It is suggested that too much significance may have previously been attached to small changes in acidity. The alcohol insoluble acid-hydrolyzable fraction should receive more attention.

Due to a change in personnel, certain other results, have been collected into manuscript form. These deal with the relation of catalase activity to physiological breakdown in Jonathan apples and with a study of electrodialysis of apple tissue. Results suggest that catalase activity may be higher in the early stages and lower in the later stages of breakdown than in normal apples. Electrodialysis showed no essential difference between normal apples and those showing physiological breakdown.

Preliminary work is now being done on common Delicious and certain mutations of Delicious which have been developed.

Chemistry of Oil Sprays. (E. L. Green and J. R. Neller). This study has emphasized spray combinations, especially of lead arsenates and mineral oils. The causes of flocculation and the relation of combination sprays to injury and spray residue removal have been studied. It was found that the amount of ammonia ordinarily used in casein ammonia emulsifier is in excess of the amount necessary. The stability of certain combined sprays was studied and also the effect of some salts on this stability. A suitable method for the breaking of the emulsions used has been sought. Some work also was done on the development of a method for the study of oil coverage of leaves and twigs. Preliminary work was done on a study of oil globule size in emulsions. Work was started to study the cause of foliage burning which results after certain spray combinations.

Nature of Watery Whites in Eggs. (J. L. St. John). The results described in last year's report are being published in the *Journal of Rheology*. Hydrogen ion determinations on egg white showed that the thick was more alkaline than the thin portion. After two years' storage, the reverse was true, the thin being the more alkaline of the two portions. In developing a method applicable to the determination of bound water in egg white, it was shown that all the free (unbound)

water is frozen at -12.5°C , while the remaining water (bound) is not frozen at temperatures ranging down to -35°C . The average amount of bound water in the thick white is about 26 per cent as determined by this method. A study of the beating ability of the white of firm and watery eggs suggests that the discrimination against watery eggs on this basis is not justified. The latter give a larger volume per unit weight than the firm eggs. Storage has little effect on the beating ability of the white. The thin portion of the white beats better than the thick. These results, together with others, have been prepared for publication. The studies are being continued.

Arsenical Residue on Fruits. (J. R. Neller). This project was discontinued during the year. Material previously accumulated on the accuracy of the Gutzeit method and on the sampling of apples for arsenic determination was published. The effect of certain variations in procedure, the accuracy of duplicate determinations and a method of preparing sensitized strips are discussed. Several precautions are listed. In sampling, it was concluded that two samples of six apples each constitute a sufficiently accurate sample. Some information on a wax solvent method of cleaning apples was collected into manuscript form. It was found that when apples have become coated with wax and oil, the hydrochloric acid method of removing arsenic is more effective if preceded by previously dipping the apples in methanol.

Poultry Nutrition. (J. L. St. John, Otto Johnson, Iva Hansen Flor, T. Aspinall, Harold Gerritz, and Marvel-Dare Fellows, in cooperation with the Division of Poultry Husbandry). A continued study of methods for the determination of excreted uric acid has resulted in the development of a method apparently suitable for this purpose. Lack of such a method has undoubtedly been a factor in the slow development of poultry nutrition work in the past. With this method, work is being expanded on protein metabolism of poultry. Methods of handling samples have been perfected. Work on endogenous nitrogen metabolism and biological value is being continued. The work on synthetic rations previously described was continued this year and the advantage of certain modifications of previous synthetic diets was shown. The results published in *Poultry Science* 9:320 were followed up by a study of the effect of different protein levels on egg production with an accompanying study of nitrogen metabolism. The analytical work on this has been completed and the results are being organized. The work on protein supplements is being continued including additional protein supplements.

Bindweed Eradication. (J. R. Neller, in cooperation with the Division of Agronomy). The work on the effect of chlorates upon

the catalase activity of the roots of the bindweed (*convolvulus arvensis*) has been assembled into manuscript form. The data suggest a relation between catalase activity and the expected effectiveness of the treatment of the bindweed by chlorate spray. Catalase activity was reduced by application of chlorates. There seems to be some relation between catalase activity and the quantity of sodium chlorate applied. Lowered catalase activity of the roots to a depth of two feet may be related to effectiveness in killing the bindweed.

Service Work. In addition to cooperative work with the other divisions this division has continued to do analytical service work for other divisions of the Experiment Station whenever possible.

Many samples are received from private individuals which cannot be analyzed because of lack of time and funds. Qualitative tests are made on samples, but quantitative analysis cannot ordinarily be made unless a fee is received to cover the cost of the work.

Some Needs of the Division. Additional help and funds should be provided for work upon some of the projects discussed above and for work on other problems. The work on watery whites of eggs has progressed to a point where a large amount of analytical work should be done to develop further the interesting information which has already been obtained and to work upon other phases of the problem which appear to be important. The minimum of additional work devoted to this problem should be a fellowship established for the purpose. An additional full time man should be available for chemical work upon the problem of winter injury to fruit trees so that an intensive study of this important problem might be made.

The need for work in dairy chemistry has previously been emphasized. Work in cereal chemistry is important in this state. A problem of much value to the latter two important industries concerns the use of milk powder in bread and other cereal products. This should be attacked both from the standpoint of cereal chemistry and nutrition. The full time of at least one additional man should be devoted to this problem. A further study of the utilization of soft wheat flours should be of much value. An intensive study of the chemical utilization of crop by-products should be of much value, especially to the wheat farmer, the lumber industry, and the horticultural industry.

STATE CHEMIST

J. L. St. John in Charge

The State Chemist's work has been of a nature practically identical with that of last year, and results and recommendations made in

last year's report apply equally well this year. The following quotations from the last report apply to this year's work:

"Analysis is made of official samples received from the inspectors of the State Department of Agriculture. The larger part of the work has been on samples of commercial feeding stuffs, together with work on foods, commercial fertilizers and insecticides.

"The feed law and rulings require the manufacturer to guarantee a minimum per cent of protein and fat and a maximum per cent of crude fiber and ash, with a statement of the per cent of moisture. It also stipulates that the crude fiber shall not exceed 10 per cent. A considerable proportion of the samples do not meet the guarantee accompanying them. Some samples are found to contain more fiber than guaranteed, while others contain less nitrogen or fat. In some cases the discrepancy is rather large. Others are found not to conform to the specified list of ingredients.

"The results obtained reemphasize the fact that there should be additional facilities for enforcing the law. A law including a registration fee and tag tax for feeds and fertilizers sufficient to handle all costs of inspection and analysis so that the funds available would automatically increase as the amount of work increases is highly desirable. Such a method would be similar to that employed by other states. It should provide sufficient funds for analysis of at least one to two samples of each brand of feed, fertilizer and insecticide registered and sold in the state. Funds should also be provided for greatly increased work on foods. Legislative provisions should be made for the publication of results obtained by the State Chemist, which is not now permissible.

DIVISION OF DAIRY HUSBANDRY

E. V. Ellington in Charge

A Study of the Correlation between Cream Quality as Determined by Various Tests and Butter Quality. (H. A. Bendixen and L. A. Black). From a study of 31 churnings, it appears that an accurate classification of churning cream based upon flavor as determined by tasting and smelling is impossible. Many slight off-flavors did not markedly lower the score nor reduce the keeping quality of the resulting butter as judged by three reputable butter graders in different sections of the country, although marked off-flavors in the cream reduced the flavor score of the butter very much. Some slightly off-flavored cream made 37 or higher score butter, but markedly off-flavored cream usually produced butter of less than 34.5 score.

A more regular gradation of butter scores resulted from the classification of cream by acidity than by flavor. For each increase in acidity and serum acidity of the cream, there was a definite decrease in the score of the resulting butter. An acidity of .2% or less, a serum acidity of .3% or less, or a P_w of 6.6 or above seemed to be essential in the cream for the highest quality of butter, especially when keeping quality is desired. A moderate acidity of .2% to .6% affected the butter score more than a slight off-flavor, but a marked off-flavor was much more deleterious to the quality of the butter than high acidity alone.

Other tests more or less based upon acidity such as hydrogen ion concentration, a modified hot water test, and the alizarin test failed to grade cream any more accurately than the acidity test, and being more indefinite and less practical in practice have no advantage over the acidity test.

Five grading systems as incorporated in state and provincial regulations were applied to the experimental cream. None of these systems, if taken literally, classified the cream absolutely as desired.

The Washington state grading system, however, in the light of these limited experimental data appears useful. This system permits in the highest grade called "Special", only clean flavored cream of .2% acidity or less. In the second grade called "First" for most satisfactory results in the light of these experimental data slight off-flavors, such as slight feed flavors, might well be permitted. Under practical conditions in the operation of the Washington system, such slight off-flavors are probably overlooked, although it might be best not to permit them in the highest quality of "Special" grade of cream.

Not enough cream of over .6% acidity was included in these trials to state whether fairly clean flavored cream of such an acidity should be included in the second or third grade. Although there are some indications that clean high acid cream may make a fair quality butter, the fact remains that usually such cream has acquired off-flavors along with the high acidity, but that these off-flavors may be hidden by the acid and remain undetected. For this reason, the acidity limit of .6% should at least for the present be retained as a factor of safety in this grade. No markedly off-flavored cream should be permitted in the first two grades of cream.

The Iowa system which specifies for the second highest grade cream of absolutely clean flavor and an acidity not to exceed .4%, seems too severe in its acidity requirement for this grade.

The use of the hot water curdling test, which is the principal point of variance of the Wyoming system from the Washington

system, is less satisfactory because of less definite results, than the use of the acidity test.

Flavor scores by different well-known judges in different parts of the country varied as much as five points on identical samples of butter. The disagreement seems to be due to lack of standardization and to a difference in quality of butter desired. The flavors of the cream were reflected somewhat in the flavor criticisms of the butter, but the terminology varied considerably.

Bacterial Content of High Quality Milk. (L. A. Black and R. A. Graham). Samples representing high quality milk of low bacterial content have been divided into equal portions, one-half being pasteurized. These samples were stored at 45° and 65° until a decided off-flavor developed.

Samples of the raw and pasteurized milk were then stored at 45° F. and 65° F. until decided off-flavor developed. Daily determinations were made of the per cent acidity, speed of reduction of Methylene Blue, and Janus Green and the reduction of P_{10} as determined by the Devereaux modification of the Cooledge Method. After the samples stored at the different temperatures developed decided off-flavors the total agar count and acid producers were again counted and compared with those of the fresh sample. The predominating types of organisms responsible for the breaking down of the milk sample were picked and a further study in an effort to determine their effect on the flavor and odor of the milk is being made.

Organisms isolated from milk drawn aseptically from the udders of cows producing low count milk have been reinoculated into sterile milk and this effect on the flavor and odor observed. A study of this data seems to point to the probability of specific organisms being responsible for certain off-flavors in milk of low bacterial content.

The Effect of the Temperature of Storage of Acidophilus Milk Upon the Number of Viable Organisms. (L. A. Black). The work of this project is completed and the data summarized. Two technical papers -- "The Viability of Lactobacillus Acidophilus and Lactobacillus Bulgaricus Cultures Stored at Various Temperatures" and "The Effect of Acidity on L. Acidophilus Cultures" are in press.

The Use of Dry Skimmilk in Feeding Dairy Calves. (E. V. Ellington and J. C. Knott). The calves used in the experiment are fed for two weeks on whole milk. A week is taken to change them to re-made skimmilk. They are fed the re-made skimmilk for two weeks and a week is taken to discontinue the use of the re-made skim, so that after six weeks of age, they are receiving no liquid milk.

A grain mixture is fed which contains 25% of dried skim milk. Calves are encouraged to eat this grain mix as early in life as possible and by the time they are six weeks old, they usually are consuming close to two pounds per day. The calves are continued upon this grain mix until six months of age.

Of the calves that have finished six months, in only one case has the average gain been lower than the normal gain according to Eckles' standard. The average gain in body weight per day has been 1.5+ pounds. In appearance, the calves have compared very favorably with those raised on separated skim milk under good dairy conditions.

A study of the Gestation Period of Holstein-Friesian Cattle. (J. C. Knott and E. V. Ellington). The average duration of 2824 gestation periods of Holstein-Friesian cattle terminated with single births was 279.9 ± 0.063 . Male calves were carried one day longer than females. The average gestation period of twins was 4.4 days less than the average for single births. The age of the cow had little influence on the length of the gestation period. The gestation periods of individual cows varied greatly in length with but few cows having uniform gestation periods.

Except in a few instances, there was little correlation between the length of time an animal was carried in dam and the length of the gestation periods of the calves she produced.

Official Testing. (J. C. Knott). There was an increase in Official Testing in the state of Washington for the year ending June 30, 1930, as compared with the previous year. There has been an average of one more herd per month and 55 more cows tested each month. The number of seven-day tests continues to decrease materially. Much interest has been shown in the Herd Test and with the adoption of the new uniform rules by all breeds, it is believed that this type of testing will greatly increase.

AVERAGE PER MONTH July 1, 1929 to June 30, 1930

Breed	Herds Testing	Cows Tested		Kind of Test	No.
		Per Herd	Cows Tested		
Ayrshire	3.0	10.9	32.8	One-day	89.2
Brown Swiss	.5	1.0	.5	Two-day	129.3
Guernsey	10.0	4.5	45.1	Seven-day	.5
Holstein	6.4	24.1	154.3	Retests	5.8
Jersey	7.6	3.7	28.3	Herd test	33.8
				Check tests	8.2
Average per month	27.5	9.5	261.0		266.8

During the year many exceptional records have been completed. Lockwillow Cascade Marie, a Holstein cow owned by H. H. Faust, Ellensburg, completed a 365-day record as a senior four-year old in which she is credited with producing 30,192.8 pounds of milk containing 1,100.6 pounds of butterfat.

The Holstein cow, Carnation Ormsby Wayne, owned by the Carnation Milk Farms, Carnation, Washington, completed a world's record for milk production in the junior two-year old class. This cow produced in 365 days 28,329.4 pounds of milk and 934.4 pounds of butterfat.

The Jersey cow, Golden Glow Cloverfield, owned by Cloverfield Farms, Olympia, Washington, established a new state record in Class AAA as a senior four-year old. She is credited with a production of 13,354 pounds of milk and 684.67 pounds of butterfat in 305 days.

The Jersey cow, Glenwood's Morocco May, owned by A. G. Hamann, Buckeye, Washington, established a new state record for junior four-year olds by producing 16,674 pounds of milk and 827.51 pounds of butterfat in 365 days.

The Guernsey cow, Galaday's Pride of Cottonwood, owned by A. B. Croop, Toledo, Washington, has completed a state record of 18,708.2 pounds of milk and 877.5 pounds of butterfat in 365 days as a mature cow.

The Guernsey cow, Governor Glen's Royal Maid, owned by D. W. Barclay of Burlington, Washington, established a new state record in Class DDD. In 305 days as a senior three-year old she produced 11,332 pounds of milk and 601.9 pounds of butterfat.

The Guernsey cow, Primrose of Valley Gem, owned by the Valley Gem Farms, Arlington, Washington, established a new state record in Class CCC. As a junior four-year old in 305 days she produced 10,225.9 pounds of milk and 517.5 pounds of butterfat.

DIVISION OF ENTOMOLOGY

R. L. Webster in Charge

Potato Flea-Beetles. (R. L. Webster and William W. Baker). Investigations under this project were continued in cooperation with the Western Washington Experiment Station and with the County Extension Agent in Grays Harbor County. Other collections of the beetles east of the Cascade Mountains furnished additional evidence that *Eptitrix cucumeris* is not a factor in eastern Washington. In western Washington, however, both *Eptitrix cucumeris* and *Eptitrix subcrinita* are found. The former species is by far the more abundant in those counties where damage to potato tubers has occurred in recent years.

General observations in Grays Harbor County in 1930 corroborated those made in previous years to the effect that late planted potatoes were less damaged than those planted early in the season. This was particularly true in fields more or less isolated from early potatoes. Late planting, however, did not assure freedom from tuber injury, where a series of plantings at different dates were made in the same field. In a series of plots at Montesano the late plantings were damaged to a considerable extent. This, however, was likely due to the position next to earlier planted rows.

Oil Sprays. (A. Spuler). Experimental work on oil sprays was conducted cooperatively with the divisions of horticulture and chemistry. This work has been in progress for five years in the Wenatchee Valley. The purpose of these investigations is to determine what types of oil are best suited for spray purposes and what effect such factors as viscosity, emulsions, refinement, spray concentration and time of application have on the insecticidal or phytocidal properties of oil sprays used in dormant and in summer applications.

In the work with oils for dormant use it has been shown that an oil spray used in the dormant period of tree growth should have specifications differing considerably from those required in a summer oil.

Oils ranging in viscosity from 100 to 255 seconds Saybolt have been found satisfactory for dormant use.

Emulsifiers have an important bearing on the phytocidal properties of the oil. The so-called "quick breaking" emulsions break immediately after application to the tree and leave a heavy oil deposit on the sprayed tree, the thickness of the oil film depending largely on the length of time the spray has been applied. Tests of various oil emulsions showed the oil content in the "run off" to vary from 26 per cent to 74 per cent. The more stable the emulsion the higher the oil content in the "run off." The oil deposit has a direct bearing on plant injury, if the oil is applied after the buds first begin to break. Trees sprayed with a four per cent quick breaking emulsion receive a dangerous amount of oil in the lower limbs. A reduction in oil concentration in the tank to offset this generally is accompanied by lack of insect control in the top of the trees or portions not easily hit. General suggestions to growers have been to use stable emulsions to overcome this tendency to build up oil deposit, in order to prevent injury to trees.

Refinement of the oil is less important since oils ranging in sulfonation test from 50 to 85 have given good results when applied during the dormant season.

A four per cent oil emulsion was found to be necessary to control San José scale. This spray also is effective in destroying a high

per cent of red spider eggs (European red mite and clover mite). Aphids are best controlled if the oil spray is delayed until the bud tips show green. However, a spray at this time is not advisable because of possible injury to trees.

Oil sprays for dormant use should be applied while trees are still dormant. Good control of San José scale was secured when oils were applied as early in the year as January 19. Oil applied at this time was not accompanied by injury to trees.

In the work with oils for summer use lubricating oils have demonstrated their value as a summer treatment for such insects as red spider, codling moth, aphids, and leaf hoppers. Red spider species (*Paratetranychus pilosus*, *Tetranychus telarius*, *Tetranychus bimaculatus*, and *Bryobia pretiosa*) have been readily controlled during the summer with an oil spray containing one to one and one-half gallons of oil emulsion per 100 gallons of spray.

Oil sprays used alone were ineffective in controlling the codling moth, although they killed from 80 to 95 per cent of the codling moth eggs actually hit by the spray. Their use in combination with lead arsenate resulted in excellent control. Repeated tests have shown that an oil-lead arsenate combination spray reduces worm infestation in fruit very materially. The oil in this combination kills a high per cent of the eggs and increases the insecticidal value of the lead arsenate. Thirty per cent of the larvae placed on apples sprayed with this combination were able to enter the fruit as compared with 45 per cent where lead arsenate alone was used.

Oil sprays for codling moth control were found to be most effective if applied at the height of the egg-laying period of both broods or as second brood sprays. The use of oil with lead arsenate after July 1 increases the cleaning problem to a considerable extent and for that reason is not generally recommended for these late sprays. The use of nicotine sulphate 1-1600 with the oil and in place of the lead arsenate gave excellent results when applied in second brood sprays. It was found that this combination could be substituted for lead arsenate in any of the cover sprays with results generally better than that of lead arsenate used alone.

The oil-nicotine sulfate combination is also an excellent clean up spray for such insects as aphids and for red spiders.

Oil sprays when applied in more than three applications have a tendency to cause a reduction in size of fruit and should not be used in more than three applications. Three applications of oil with lead arsenate or nicotine-sulfate in a spray program properly timed, have given excellent control of the codling moth.

Refinement in summer oils is a very important factor since unrefined oil is more or less toxic to plants. Tests at Wenatchee have shown that an oil should have a sulfonation test not less than 85 per cent.

Oils having a viscosity range of 60 to 75 have given best results in the Wenatchee Valley. Oils with viscosity range below 60 are not as effective in codling moth and red spider control unless relative larger amounts are used and oils having a higher viscosity than 75 have proven injurious to trees if applied in more than two applications.

Summer emulsions need not be stable and in some combinations have given better results if of the quick breaking type.

Codling Moth. (A. Spuler). Investigations in the control of the codling moth, *Carpocapsa pomonella*, have been continued in the Wenatchee Valley. During the past season tests were conducted in the insectary and in the field.

Some 10,000 codling moth eggs and larvae were used in experiments to determine the relative efficiency of various insecticides, both contact and stomach poisons. These tests have shown that lead arsenate is only partly effective in preventing worm entry. Forty-five per cent of the worms placed on apples sprayed with lead arsenate 2-100 gained entry into the fruit without being poisoned. Increasing the amount of lead arsenate beyond three pounds per 100 gallons did not materially increase control. Twenty per cent of the worms entered through a spray coverage of eight pounds per 100 gallons.

A uniform coating of spray on the fruit gave better control than a spot or blotched coverage. The addition of calcium caseinate spreaders of soap to lead arsenate did not increase control since these materials were responsible for a very material reduction in deposit of lead arsenate per unit area.

Fish-oils when combined with lead arsenate increased the lead arsenate deposit on the fruit and at the same time produced a more uniform coverage. This combination was more effective in preventing worm entry ten days after spraying than was lead arsenate immediately after spraying. The residue placed on the fruit by this combination was very hard to remove.

Nicotine sulfate 1-800 was effective in destroying 80 per cent of codling moth eggs and in preventing entry of worms placed on sprayed apples for one or two days after spraying. A few days later this material afforded no protection to the fruit. Combination of such material as glycerine or syrup with nicotine sulfate increased the period over which the nicotine sulfate was effective but field tests showed this combination to result in injury to fruit.

Pyrethrums used in combination with oil and with lead arsenate gave variable results depending on the particular extract of pyrethrum used.

Field tests were conducted largely to determine a spray program that could be used to best advantage from the standpoint of codling moth control, red spider, and aphid control, spray residue removal and tree or fruit injury.

Oil in combination with lead arsenate and nicotine sulfate was applied in different cover sprays throughout the season. These tests showed that an oil combination is most effective in the second brood sprays. The oil-nicotine sulfate in the second brood sprays did not increase the cleaning problem.

Fish-oils used at the rate of one quart per 100 gallons showed some ovicidal value and great larvicidal value throughout the season.

In field tests a spray program in which an oil-lead arsenate combination was used at the height of the egg-laying period of the first brood (first cover) followed by three applications of lead arsenate alone or in combination with fish-oil for the first brood and two applications of oil-nicotine sulfate, in which the oil was used at one per cent and the nicotine sulfate at 1-1600 for the second brood, answered practically all of the requirements for a complete spray program.

General Studies on Codling Moth. (A. Spuler). About 1400 codling moth larvae collected from bands were placed in a cage placed about the base of a living tree. All these larvae entered the bands within a week's time. Moth emergence from them began on April 31 and extended to July 11, 1930.

Moth traps again were used to determine spray dates. Traps all over the valley showed that the time of activity in various parts of the valley is strikingly similar, even though all other conditions such as temperature, soil, cover crop, and exposure may be different.

DIVISION OF FARM MANAGEMENT AND AGRICULTURAL ECONOMICS

Geo. Severance in Charge

Development of Profitable Farm Set-ups for Types of Non-Orchard Areas of the Yakima Valley. (Geo. Severance). The purposes of this study are, first, to determine the enterprises and the types of farming that are best adapted to the physical and the market conditions and market outlets of this area, and second, to secure information for developing farm plans which are likely to give best results under the conditions prevailing in the area and for adjusting these plans to meet changed price relationships as they arise. Com-

plete farm records were secured in the summer of 1930 from over 100 of the more successful farmers, quite widely scattered over the area under study. Records for another year will be secured in the summer of 1931 and enterprise records will be secured from 25 or more farmers for each of the more important crops. The two year records will then be prepared for publication.

An Economic Study of Handling and Storing Grain. (Geo. Severance, in cooperation with the Bureau of Agricultural Economics, U. S. D. A., the Idaho Agricultural Experiment Station and the Oregon Agricultural Experiment Station). This project is designed, first, to determine the relative economy of bulking and sacking grain on the farm by obtaining farmer experience in shifting from sack to bulk handling, together with details of necessary changes and additions to equipment, as well as comparative labor costs in harvesting and handling the grain and degree of operating efficiency under each method; and second, to determine the relation of present storage, handling and transportation facilities at local, intermediate and terminal points to the problem of shifting from sack to bulk handling on the farm.

Data were secured by personal visitation from several hundred grain growers in the grain growing areas of eastern Washington, eastern Oregon, and northern Idaho who already have changed to bulk handling, and a large number of records from operators who are still following the sack method. In addition to these data from farmers, the representative of the Bureau of Agricultural Economics has gathered extensive storage data from both local shipping points and the terminals. These data will be assembled and prepared for publication under the direction of the Bureau of Agricultural Economics.

The Economic Relation of Tractors to Farm Organization in the Grain Farming Area of Eastern Washington. (E. F. Landerholm). The purpose of this study is to determine the cost factors of tractor operation for the grain areas of eastern Washington and to develop plans for reducing these costs. A study of the relation between size of tractors and size of farms under different types of topography and farming will be made; the cost of performing the principal field operations ascertained; the optimum combination of tractor power and horse power determined for various conditions; and the most efficient sizes, types and combinations of tractor equipment for the most prevalent sets of conditions analyzed. Blank forms have been distributed by personal visitation to tractor operators who keep the records and report monthly. These original data will be supplemented by data already secured by this and other experiment stations and tractor manufacturers and dealers.

Community Organization in Selected Communities in the State of Washington. (Fred R. Yoder and Harvey W. Starling, in cooperation with the Bureau of Agricultural Economics, U. S. D. A.). The objects are: (1) To study the various rural community organizations, including the Granges, Farmers' Union Locals, Farm Bureau Locals, 4-H Clubs, Home Economics Clubs, Women's Clubs and Community Clubs, to determine their relative effectiveness and conditioning factors entering therein, (2) To endeavor to determine some of the factors and qualities that make a good leader, and (3) To study the relationship between leadership and community organization.

A large amount of data was gathered through personal interviews during the summers of 1929 and 1930 regarding both community organizations and factors of leadership. Data were secured from organizations and leaders representing counties in both eastern and western Washington. These data are being prepared for publication and will be issued in two bulletins: one on community leaders and one on rural community organizations.

Economic Aspects of Fruit Storage in Washington. (Chester C. Hampson). Investigations have been made to determine the adequacy and character of cold storage plants available at both the coastal and the initial shipping points, and also what the optimum amount and character should be at these two places. Further objects in connection with this study are to determine costs of operating cold storage plants of different types and the essential features of successful storage plants, and to make a study of the amount and distribution of investment in the different types of storage plants. Data have been compiled on storage charges in (a) cooperative and commercial plants at initial shipping points, (b) cold storage plants at the ports, and (c) cold storage at eastern and mid-western plants that handle considerable quantities of Washington apples. These data have been secured in the State of Washington by personal interviews with operators of cold storage plants in the principal fruit regions and on the coast, and from leading fruit growers and managers of shipping organizations. Information regarding cold storage outside the state has been gathered by correspondence. The study will be published in bulletin form.

Factors Affecting the Price of Washington Apples. (Chester C. Hampson and E. F. Dummer in cooperation with H. R. Tolley and M. R. Cooper, Bureau of Agricultural Economics, U. S. Department of Agriculture). The purpose of this project is to determine as nearly as possible average prices received by Washington apple growers, the different charges made for western marketing services and other factors influencing the returns to growers. Bulletin 242, which gives average apple prices net to the grower and average f.o.b. for six years

beginning with 1922, as well as average costs of marketing services, has already been published. The work is being continued and a study of daily sales of Washington apples on the New York and Chicago Auctions is being made to show price differences for apples of different varieties and grades throughout the marketing seasons and especially to what extent auction price differences for apples of different sizes within the same variety and grade are in harmony with differences in the returns made to growers by carlot buyers and marketing organizations.

Causative Factors of Success or Failure in the Development of Washington Cooperatives. (E. F. Dummeier). A large amount of information on the present and past operations of cooperative marketing organizations in the state of Washington has been collected. An analysis of this, and further information to be collected, will be made in order to accomplish the objective of this project, which is, "to determine the causative factors of success or failure in the last five years' growth and development of Washington cooperative marketing organizations."

Trade Practices in the Marketing of Washington Apples. (E. F. Dummeier). A considerable amount of information has been collected on trade practices in the marketing of Washington apples, "with particular reference to methods of quoting prices, making and developing sales, and making collections," in regard to which there is dissatisfaction and differences of opinion among those engaged in marketing. The information already collected will be supplemented and further investigation made in the hope of arriving at conclusions which will make possible improvements in some of the questionable current practices.

An Analysis of the Economic, Operating, and Business Set-up of Successful Fruit Packing Plants. (E. F. Dummeier). Information has been collected on classification of costs and actual costs for different elements or parts of the total cost for a number of fruit packing plants in the Wenatchee and Yakima Valleys. This will be added to and other investigations made in order to determine the essential economic and operating features of a successful fruit packing plant.

Financing Washington Cooperative Organizations. (E. F. Dummeier). The object of this study is to determine present practices and their various degrees of efficiency, and needed and desirable improvements in present methods of financing cooperative marketing organizations in Washington. A large number of financial statements have been collected, showing the extent and character of assets, liabilities and net worth, methods of securing fixed and operating capital, rates of interest paid, additions to fixed and operating capital by profits from the enterprises and from outside sources, and other financial particulars about Washington cooperative marketing associations.

These will be added to until all cooperative marketing associations within the state are included. Methods of compilation and summarization of information shown on these reports are now being worked out in detail. This will be continued and supplemented and results analyzed and published.

An Economic Study of Orchardring in the Yakima and the Wenatchee Areas. (Neil W. Johnson). This study was completed and the results were published in two bulletins. See bulletin description, page 70.

DIVISION OF HOME ECONOMICS

Dean Florence Harrison in Charge

Efficiency of the Home Laundry Plant. (Miss Evelyn H. Roberts). Laundering and its many phases have been studied with relation to the farm home. Water softening compounds have been rated as to cost and effectiveness. A few samples of water from various parts of the state have been tested for hardness, varying from soft (3°) to very hard (15°). Soaps on the local market have been tested for water content, free alkali content, sudsing and detergent properties, especially with reference to cost.

Over 90 experimental washings have been made to test the relative efficiencies of various types of washing machines, time expended and electrical consumption under advantageous conditions. Another series of washings was made in Pullman homes to continue the comparative tests on washers. The types on the market are arranged as follows, in order of speed of cleaning: (1) agitators, (2) vacuum cups, (3) cylinders, (4) oscillators. Ninety ironing records have been studied for the electrical consumption of irons and ironers and the time to iron various pieces by both methods.

Energy metabolism tests with the Benedict knapsack equipment have been made on ironing methods with the following tentative results: ironing, sitting at an ironer—40% above basal metabolism (B. M.) rate; ironing with an electric iron while sitting—75% above B. M.; ironing with an electric iron while standing—95% above B. M.; and ironing with sad irons while standing, involving trips to stove—105% above B. M. This work is to be continued in Project IV, Human Energy Cost in Household Tasks.

Several pieces of electrical equipment were placed in farm homes and the electrical consumption metered and time records kept for a period of several months. Ironer records in two homes, as well as laboratory records, show savings in time in ironing a number of pieces

in comparison to hand ironing, with the electrical expenditure of approximately 1.1 kilowatts per hour, only twice that of the flat iron (0.55 K.W./H.).

Standards for Cooking Vegetables in the Electric Oven. (Miss VeNona W. Swartz). Progress was made on this project along the following lines: oven performance, efficiency of oven utensils, water analysis, "doneness" of vegetables, and actual vegetable cooking.

The first problem was a study of the performance of five electric ovens of different manufacture. These were rated on the basis of utilization of space, heating ability, heat retention, evenness of heat, and thermostat performance. A comparison was made between the fuel costs to maintain the same temperature in different ovens. The two ovens found most satisfactory were used for all subsequent tests.

For most vegetable cooking work it becomes necessary to use a pan or utensil of some sort. To find what material is best in an oven utensil, a comparison was made of 17 utensils of six different materials; light and cast aluminum, stainless steel, glass, china, enamel, and cast iron. In speed of heating of a given quantity of water under standard conditions, cast iron was definitely the fastest; glass, china, and enamel next; and aluminum and stainless steel slowest. The difference between the fastest and slowest was the difference between 27 minutes and 54 minutes. In efficiency, there is this same order, the most efficient (cast iron) being 25 per cent efficient, and the least (aluminum), 14 per cent.

Since water is used in most vegetable cooking, samples of water from 19 different localities in 13 different counties of the state were tested for alkalinity. A good cooking water should have a pH of 8.0 or beyond, at least after a minute of boiling. All except five of the raw samples were alkaline; only one was definitely acid. After a minute of boiling, all except one, from Pacific County, were 8.0 or beyond. Soda need not be added to most of the cooking waters of the state to maintain the green color in vegetables.

The Vicat needle was discarded as a penetrometer because it was not capable of fine adjustment of weight; also because of the lack of uniformity of vegetable samples. Even in such a homogeneous vegetable as the Irish potato, there is such a wide variation in firmness from piece to piece in the same potato, and between tubers, that the results are vitiated. It is plainly not applicable to such vegetables as spinach and celery.

At present the point of emphasis is the deriving of tables showing the time and amounts of water necessary for baking vegetables at different temperatures in the electric oven. Twelve vegetables have

already been studied and work is being extended to others. Present cooking practices are being investigated, and recommendations for improved methods will be made.

DIVISION OF HORTICULTURE

E. L. Overholser in Charge

Measurable Characteristics of Ripening Apples. (E. L. Overholser and F. L. Overley). Reports from different sources seem to indicate that the red mutations of the Delicious do not increase in size as well after they become colored as does the fruit of the common or striped standard variety of Delicious. Four measurements were made of 100 fruits each of the original Richared Delicious tree and of fruits on adjoining common Delicious tree in Richardson's orchard at Monitor. The data for one year indicate that the Richared obtained even somewhat better size than the common Delicious. Apparently when the Richared is grown under the same conditions of moisture, pruning and thinning, there will be but little difference in growth of fruit after color develops.

Winter Injury. (E. L. Overholser, F. L. Overley and L. L. Claypool). A study made of winter injury during 1928 and 1929 is summarized in Bulletin No. 236 entitled "Collar Rot of Apple Trees" by Dr. J. R. Magness. Early in the season of 1930 observations and surveys were made in different sections of north central Washington to determine the extent of winter injury following the unusually severe winter temperatures of 1929 and 1930. Three types of winter injury are found in Washington orchards—root killing, collar rot and top injury. Considerable root injury resulted where the ground was unprotected by snow, cover crops, weeds, and other protective coverings such as sawdust, paper mulch, and other materials. Trees one to eight years old suffered most severely from root killing while older trees were injured mostly at the crown, and some of the shallow roots were killed. Greater injury to older trees resulted by a drought condition during the fall, either by lack of fall rains or where the irrigation water was cut off too early in the season. Tramping and packing of the soil, before the ground froze, by sheep or roads through orchards resulted in increased root injury. In districts with heavy snow coverage top injury often resulted from long continued cold weather especially if the soil went into the winter dry. Laboratory tests show that apple roots are injured when subjected to a temperature of 17°F.

Attempts are being made to study some of the factors responsible for both root and top injury to certain varieties of trees. This study includes the possible effects upon soil temperatures of cover crops;

early and late fall irrigation; covering the ground about the base of trees with material such as paper mulch, sawdust, weeds and trash; and clean cultivation, on both root and top injury. The susceptibility of different varieties to low temperatures under these different conditions is being noted. Observations are also being made on the response of winter injured trees to different treatments such as pruning, irrigation, and fertilizing.

Development of Methods of Producing Hardy Apple Stock. (O. M. Morris and L. L. Claypool). Three thousand hardwood cuttings of Delicious, Winesap, Jonathan, Rome Beauty and Spitzenberg apple varieties were planted in the nursery after being treated with solutions which have been reported to be of value in stimulating root productions. Nitrate of soda and ammonium sulphate solutions were used on a greater number of cuttings than any other treatment. All of the cuttings failed. Some retained a few green leaves all summer, but failed to produce roots. A study of conditions suggests that the extreme dryness of the summer was sufficient to prevent cuttings developing in the ordinary way.

Seedlings of 19 different varieties of apples were grown in the nursery. Among these varieties were McIntosh, Northern Spy, Snow, Wolf River, Milinda, Haralson, Patton's Greening, and Wealthy, all generally recognized as very hardy and highly resistant to winter injury. These seedlings will be experimented with the coming winter in the test of methods for determining hardiness of apple stock.

Orchard Cover Crops. (O. M. Morris and F. L. Overley). Attempts to seed cover crops in orchards of large fruiting trees generally have not been successful. The same type of cover crop gave a good stand of the crop when planted in orchards of young trees. Late seeding in irrigated orchards uniformly has given a stand only along the edge or close to the irrigation rills and very little in the space between irrigation rills. The sprinkler system of irrigation in one season's trial has given a much better start of cover crops than the rill system.

In a study of the distribution of apple tree roots in the soil, it was found that the number of roots in any cubic foot of soil decreased as the distance from the tree trunk increased. The greatest number of small roots usually was found within the top 18 inches of soil. The depth to which the roots go depends upon the type of soil and subsoil. The roots increase in number and dimensions as the soil increases in fertility.

The rate of water removal from the soil by the tree seems to be nearly in proportion to the number and evenness of distribution of the roots in the soil. The soil moisture near the tree reduced very

rapidly after each irrigation and the moisture exhaustion from the soil gradually spread from the tree to the outer area reached by the roots.

The young trees do not have as many roots within short distance from the tree trunk as do the older trees and do not, through water shortage, have such an effect in starving and preventing cover crop growth as do the older trees. The measurement of the cover crop and the tree roots immediately under the cover crop indicate that the rapid exhaustion of the water supply relatively close to the tree is often as influential in preventing a cover crop growth development as is shade.

Orchard Fertilizer Investigations. (E. L. Overholser and F. L. Overley, in cooperation with the Department of Soils). The fertilizer investigations in the Wenatchee district were begun in 1927.

The fourth crop of fruit has been harvested from one series of plots where nitrogen; potash; phosphorous; nitrogen and potash; nitrogen and phosphorous; potash and phosphorous; and nitrogen, potash and phosphorous, have been applied. Considerable difference in color of fruit, yield and size of fruit, condition of the trees, and the cover crop growth are becoming evident.

Other plots in cooperation with the Northwest Fertilizer Association were laid out and started in 1929. Additional plots in cooperation with the Wenatchee-Okanogan District Cooperative Association were started in 1929 at Peshastin, Cashmere, Manson and Omak. The varieties studied have been limited to Jonathan and Winesap apples. Near Spokane two crops have been harvested from fertilizer plots of Rome Beauty apples.

Annual records are taken on tree growth as measured by tree circumference and terminal growth, leaf area and weight, leaf scorch and burn, on fruit set and June drop; per cent of fruiting and non-fruiting spurs, pollination response, and fruit bud winter injury; production per tree as measured by the total number and total weight of apples; grade as determined by condition, maturity, color and size; the keeping qualities as measured by pressure tests, breakdown, soft scald; and physiological response as measured by respiration intensity, resistance measurements of tissue and juice of fruits, and pH determinations of fruit juice.

Sprinkler System of Irrigation. (F. L. Overley, E. L. Overholser and O. M. Morris, in cooperation with Agricultural Engineering, [Committee on Relation of Electricity to Agriculture], Agronomy, Entomology, Plant Pathology, and the office of Western Irrigation Agriculture [Irrigation Branch Station, Prosser], Division of Horticulture and Plant Diseases [Wenatchee Laboratories] of the U. S. Department of Agriculture). Investigations have been under way for

one season on the study of irrigation in the orchards by the use of sprinklers both over the trees and under the trees. Studies were made of the different types and cost of installation, type and efficiency of different sprinkler heads. Some sprinkler heads were found to be more uniform in distribution of water than other types.

The same amount of water is necessary to saturate a soil whether applied by sprinklers or rill system of irrigation except for a difference in evaporation during extremely warm weather. On sandy soils with light sub-soil and on sloping land the proper amount of water could be applied with less waste by sprinklers than with the rill system of irrigation.

With overhead sprinklers about a third less arsenate of lead was found on the fruit at harvest time as compared with the sprinklers under the trees. Studies are being made of the effect of sprinklers over the trees on codling moth, aphids, red spider and other insect control as well as the control of plant diseases. Observations are being made on color of fruit, size of fruit, and tree growth in the different plots with over tree sprinklers compared with under tree sprinklers and rill systems of irrigation.

Effect of Oil Sprays on Apple Trees. (E. L. Overholser and F. L. Overley in cooperation with the Division of Entomology). The quick breaking type of oil emulsion 4% strength or stronger resulted in injury to fruit and leaf buds when applied during the critical stage of bud development or the stage immediately following the opening of the bud scales and the showing of green. The stable emulsion types of oils and lime sulfur gave no injury when applied to trees with buds in this critical stage of development.

The application of summer oils previous to July first, following a delayed dormant spray of lime sulfur resulted in injury to both the fruit and the leaves.

More than three covers of summer oils of medium to heavy viscosity applied to well loaded trees resulted in a decrease in size of the fruit and a poor set of buds and fruit the following year as compared with arsenate of lead spray.

Arsenical Residue on Apples. (F. L. Overley and E. L. Overholser in cooperation with the Division of Entomology). The relation of the spray program to cleaning tests shows that the use of mineral oils and fish oils in combination with lead arsenate makes the residue cleaning more difficult especially if oil is used with the lead combination after July first:

Investigations are being made in cooperation with the Bureau of Plant Industry laboratory at Wenatchee with different washing solu-

tions, strengths, and temperatures on the removal of arsenical residue from apples sprayed with different combinations of mineral oil, fish oil and lead arsenate.

Peach Harvesting and Storage. (O. M. Morris). Comparisons were made of the fully matured fruit harvested early, midseason and late from the same orchard. That harvested first was usually, but not always, highest in quality; that of midseason nearly as good as the first harvest, sometimes better but not averaging as good. The last material harvested was uniformly of the poorest quality, being less firm, enduring shipping and handling poorly, and developing poor quality when ripe. There were some indications that the temperature existing at the harvest time and a few days prior to harvest was an important factor in developing quality of fruit; also that very high moisture content of the soil tended to reduce the quality of fruit.

Factors Affecting Set of Fruit. (E. L. Overholser and F. L. Overley). The Bing, Lambert, and Napoleon cherries in Washington, as in Oregon and California, were not only self-sterile, but were inter-sterile. The Bing, during the 1930 season, was best cross-fertilized by the Deacon, Waterhouse and two seedlings, Parkhill and Priest No. 1. The pollen from 27 different Deacon trees proved to be satisfactory, indicating there is no tendency for this variety to produce strains which varied in pollination effectiveness. Two seedlings, Priest No. 2 and Parkhill No. 1, the "Small Black Republican" and the Deacon were effective pollinizers for the Napoleon. The Centennial was not satisfactory as a pollinizer for the Napoleon. The Deacon was self-sterile, but apparently was cross-fertilized by the Bing, Lambert and Napoleon.

The Beurre d'Anjou pear appears to be partially self-fertile under north central Washington conditions but not satisfactorily so, for the consistent set of commercial crops. The Beurre d'Anjou apparently is adequately cross-fertilized by Bartlett, Flemish Beauty, Winter Nelis, Easter Beurre and Beurre Bosc. In turn the Beurre d'Anjou will cross-fertilize the fertilizing varieties. Other factors than pollination affect the set of fruit by the Beurre d'Anjou. An important factor is vigor of tree as measured by the proportion of leaf area per individual fruit spurs and length and diameter growth made by the spurs.

Respiration Studies of Strawberries. (E. L. Overholser, Max B. Hardy and H. D. Locklin). Several commercial varieties and seedlings of strawberries yet unnamed were used in the tests, selection being based primarily on the firmness of the flesh of the fruit as determined by a pressure tester reading in grams. The relation of respiration intensity of strawberries to firmness and various other

factors was considered. The data obtained brought out the following points: (1) In the varieties tested greater firmness of flesh apparently was not directly correlated with a low respiration intensity, either with immature or mature fruits. (2) With the varieties used fruits of the firm-fleshed sorts had a higher respiration ratio than fruits of the soft-fleshed sorts. (3) The respiration intensity increased with the maturity of the fruit. (4) Both immature and mature fruits when picked at intervals in comparable stages of maturity showed a higher respiration intensity, and a higher respiration ratio as the picking season advanced. (5) The respiration intensity of any one lot of mature or immature fruits increased with each succeeding respiration interval, the increase being more marked with the mature lots of fruit. (6) No apparent depression of the respiration intensity followed the increased carbon dioxide contents attained in the respiration chambers resulting from a lengthening of the respiration period. (7) There were consistent differences between varieties in their respiration intensities which were not, however, directly correlated with the keeping quality, since the latter was affected also by the initial firmness of the berries. (8) Greater maturity of fruit was correlated with a higher respiration ratio, although no single value ever attained unity. (9) The specific gravity of the mature fruits of the varieties employed averaged slightly higher than that of the immature fruits.

Strawberry Breeding. (Max B. Hardy and H. D. Locklin, in cooperation with the Western Washington Experiment Station). Two years' records on yield, color, firmness and size of berries, as well as records of various plant characters, have been obtained on approximately one-third of the 170 varieties and hybrids selections available for study. One year's records of the same nature have been obtained on approximately another third. First year records will be obtained on the remainder in the spring of 1931.

Thirty-seven crosses were made between varieties of contrasting yield, berry color and firmness of fruit characteristics, for the purpose of studying the mode of inheritance of these characters as well as to provide an opportunity to find an improved seedling for western Washington conditions. It is expected that approximately 1000 seedlings from the crosses made in 1929 and a portion of the 5000 seedlings from the 1930 crosses will be available in 1931 for such studies.

Raspberry Breeding. (Max B. Hardy and H. D. Locklin, in cooperation with the Western Washington Experiment Station). The work in raspberry breeding for the study of the mode of inheritance of hardness has been continued. Forty-two crosses were made in 1930 using the varieties Cuthbert, King, Marlboro, Latham, Antwerp, Victory and Lloyd George, varieties which show much variation in

hardiness under western Washington conditions. But very few seedlings will be available for the inheritance studies until 1932 or 1933.

The study of the relationship of chemical composition of the raspberry canes to their hardiness has been continued in the laboratory. The object of this phase of the work is to develop a more satisfactory method of determining the hardiness of seedlings than those methods of freezing artificially or waiting for a so-called "test winter".

Potato Breeding. (C. L. Vincent). Improvements in the Irish potato have not kept pace with its increased importance as a human food. Since so many of our commercial varieties of potatoes have weaknesses that reduce yield in the district in which they are grown—as much as one-third of the crop being infected with the various types of mosaic diseases—a project was begun in 1924, the aim of which was to develop a variety of potatoes resistant or immune to the serious mosaic diseases.

A few commercial varieties have been obtained that show some degree of resistance to mosaic diseases when grown under climatic conditions at Pullman. McCormick, Keeper, Early Norther, and Jersey Red Skin fall in this class. By means of hand cross pollination, seedlings having one of the above varieties as a parent have been produced that have not become infected with any mosaic diseases when grown in the field under diseased conditions for from one to five years. Likewise, a few promising seedlings have been produced from seed of open pollinated commercial varieties that are free from diseases after having been tested several years in the field.

In a study of seedling crosses it was found that the red color of the tuber was not dominant, probably due to multiple factors or some disturbing influences, the genetic interpretation of which has not been worked out. The vine characteristics of seedlings having McCormick as one of its parents resembles McCormick in most cases. In the F_1 generation seedlings having Irish Cobbler as one of the parents, the roundish form of Irish Cobbler was dominant over other shapes.

Tests will be made in the college greenhouses to determine the resistant qualities of the selected seedlings to some ten different strains of mosaic diseases. Should any prove to be valuable in this respect, seedlings will be distributed to potato growers in the state for test purposes.

Tomato Breeding. (C. L. Vincent). Out of 189 selections made in 1927 from crosses between Bonny Best and Sutton's Best of All tomato varieties, 20 strains remained in the test plots at the end of the 1930 season. These have been carried through the F_2 generation in sufficient numbers to insure stability of the strain. It is hoped

that from these seedlings a variety can be selected having the excellent eating qualities of the Bonny Best and the superior shipping qualities of the Best of All. Further selections will be made from these plants grown in the greenhouses.

Special attention was given to storage qualities of these selections during the spring and early summer of 1930. Tomatoes were picked from each strain and placed on shelves in common storage in trays in the college greenhouse. The tomatoes were red but very firm when picked. The temperature of the storage room remained fairly constant (50° F.) throughout the test period. The storage period was considered ended when the tomatoes became unfit for sale. The average storage period for the various strains during the test period was 16, 16, 19, 21, 25, 26, 27, 27, 30, 30, 31, 31, 32, 34, 35, 35, 35, 36, and 41 days respectively. The average storage period for Bonny Best during the same period and under the same storage conditions was 25 days, and for the Best of All, 32 days.

DIVISION OF PLANT PATHOLOGY

F. D. Heald in Charge

Wheat Smut. (F. D. Heald, E. F. Gaines and H. H. Flor in co-operation with the Division of Agronomy and with the Office of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture). The work on cultural studies of the various strains of *Tilletia tritici* and *T. levis* begun by Kienholz has been continued by Doctor Flor with field studies of the different strains and variety susceptibility.

A bulletin has been prepared on the "Control of Bunt or Stinking Smut of Wheat" (F. D. Heald and E. F. Gaines) giving a summary of the work completed in recent years on the general problem of control in spring and winter varieties, including a discussion of the distribution of the two species of smut, the occurrence of physiological strains, the resistance of varieties, seed treatment and the relation of cultural practices to the amount of smut appearing in the crop.

Apple Rots. (F. D. Heald and G. D. Ruehle). Special attention has been given to the fungi causing decay of apples in cold storage. The summary of the work up to date will include the following fungi which have been isolated from cold storage apples and have been found to cause either slow or rapid decay:

Mucor piriformis Fischer; *Rhizopus nigricans* Ehr.; *Pleospora fructicola* n. comb. (*P. Mali* Newton); *Mycosphaerella tulasnei* Jancz. (*Cladosporium herbarium*); *Phoma*, No. 1; *Phoma*, No. 2; *Coniothyrium*, No. 1;

Coniothyrium No. 2; *Microdiplodia* spp.; *Gloeosporium perennans* Zeller and Childs; *Pestalozzia hartigii* Tub.; *Coryneum foliicolum* Fuck.; *Oospora* spp.; *Cephalosporium carpogenum* n. sp.; *Penicillium expansum* (L. K.) Thom.; *Penicillium verrucosum* Biourge; *Penicillium puberulum* Banier; *Penicillium olivino-viride* Biourge; *Penicillium viridicatum* Westling; *Penicillium martensii* Biourge; *Penicillium* spp. (Three undetermined species); *Sporotrichum malorum* Kidd and Beaum.; *Sporotrichum carpogenum* n. sp.; *Botrytis cinerea* Pers.; *Botrytis mali* n. sp.; *Cladosporium herbarium* L.K. (*Mycosphaerella tulasnei*); *Cladosporium malorum* n. sp.; *Hormodendron cladosporioides* Sacc.; *Stemphylium congestum* Newton; *Stemphylium congestum* Newton var. *minor* n. var.; *Alternaria tenuis* Nees.; *Alternaria mali* Roberts; *Alternaria* spp. (Three other undetermined species); *Fusarium* spp. (Two unassigned species); *Ramularia magnusiana* (Sacc.) Lind.; *Ramularia* sp. Species unassigned.; *Epicoccum granulatum* Penz.; and *Hypochnus* sp. (*Corticium centrifugum* [Lev.] Bres.).

All of the named species have occurred on commercial packs under cold storage.

Special attention is being given to the blue mold problem since the blue molds are responsible for more of the storage losses than any of the other fungi. Practices that are being recommended for blue mold control are being tested. Among these may be mentioned ozone storage which has given no appreciable retardation of blue mold growth in the tests carried out which included the measurement of 450 lesions.

Some attention has also been given to the cause of culls and the behavior of certain types of culls when held in cold storage.

Winter Injury. (F. D. Heald). The severe conditions of the winter of 1929-30 have given an opportunity of studying certain phases of winter injury. Sweet cherries in the lower Yakima Valley were severely injured, trees 25 years old or more showing very heavy killing back of branches with almost a complete failure to set fruit, while younger trees showed little or no injury. No constant differences in the hardiness of the commercial varieties were noted. Injury to apples was not confined entirely to visible tree injury but was evident in the size and quality of the fruit produced. Deformed fruits of the type known locally as "tomato apples" have constituted from 27 to 59 per cent of the culls in certain of the orchards showing the most severe injury.

Rhizoctonia Disease. (L. K. Jones). Tests of the value of treating pea seed with Semesan were made under field conditions. Two varieties of peas (Alaska and Surprise) were used. Plantings were made on April 21 and April 28. A slight increase in percentage germination of the Surprise seed planted on April 21 followed treatment of the seed with Semesan. No increased germination was noted due to Semesan treatment of the Alaska seed in any of the tests.

Mosaic and Related Diseases. (L. K. Jones). Studies on the rate of spread of tomato "streak" confirmed the results reported last year in that the disease can be transmitted readily through cultural methods in the greenhouse; also, that care in washing the hands with soap and water at intervals during pruning will greatly retard the rate of spread of this disease from one bed of plants to another. A 44 per cent less yield of fruit was produced on "streak" infected plants than was produced on healthy plants. The results of the past season tend to show that "streak" of tomatoes does not live in the soil in the greenhouse benches. A period of four months elapsed from the time of removal of the diseased tomato plants from the soil until tomatoes were again planted in the same soil.

A survey was made of the beet plantings in the Mount Vernon area to ascertain the prevalence and distribution of the mosaic disease. It was found that the disease was present in all the seed-beet plantings in that territory. The various plantings had from one to 100 per cent of the plants affected. It was definitely shown that the disease usually developed abundantly on seedling beets that were grown adjacent to mother beet plantings, and that seedling beets grown at least 300 feet away from mother beets were relatively free from the disease. It was also noted that seedling beets grown in one section of the beet-growing territory were relatively free from the disease.

During the late winter and spring about 1000 potato tubers were indexed in the greenhouse. These were sent in by 12 different potato growers to ascertain their freedom from virus diseases. Eighty-five (85) per cent of the tubers were found to be free from the common virus troubles and were returned to the farmers as stock from which to build a supply of disease-free stock for certification.

The Plant Disease Survey. (F. D. Heald, L. K. Jones, with the assistance of G. A. Newton, Western Washington Experiment Station, Puyallup, and in cooperation with the Plant Disease Survey of the U. S. Department of Agriculture). Numerous diseases were reported as in previous years, but only those which are either new to the state or present a new or noteworthy phase will be mentioned. The following troubles have not been previously reported:

Downy mildew of the hop caused by *Peronospora humuli*, Tulip mold or bulb rot caused by a species of *Penicillium*, Watermelon wilt caused by *Fusarium* sp. (This disease caused heavy losses in the region of Pasco, some fields being a total failure), Black spot of peas caused by *Cladosporium* sp. on the seeds, Spot of jonquil caused by *Phyllosticta narcissi*.

The following observations on troubles previously reported are of interest: Leaf invasions of fire blight occurred on pear in the Yakima

Valley for the third time in 15 years. Aster wilt (*Fusarium* sp.) was very severe in some gardens causing a complete loss of such varieties as Early Wonder and Queen of the Market and 50 to 60 per cent loss of mixed varieties. White pine blister rust (*Cronartium ribicola*) was present in Mt. Rainier National Park both on currants and on young pines. The entire planting of young Norway spruce in a Spokane nursery was very severely injured by a freeze in the month of June, the young terminals and all the laterals of the current season being killed.

DIVISION OF POULTRY HUSBANDRY

J. S. Carver in Charge

Breeding and Selection. (J. S. Carver). Six years have now been completed in the inbreeding work with White Leghorns and Rhode Island Reds. The average production of the inbred S. C. White Leghorn pullets for this year was 252.47 eggs. The average egg production of the Rhode Island Red pullets was 223.92 eggs. The range of egg production with the White Leghorns was from 102 eggs to 335 eggs and with the Rhode Island Reds, 190 eggs to 280 eggs.

Watery Whites. (J. S. Carver and L. W. Cassel). Observations were made on several hundred market eggs.

Methods of Feeding S. C. White Leghorn Pullets. (L. W. Cassel). Four different methods were used in feeding the standard W.S.C. laying ration:

Lot 1 was fed unlimited quantities of dry mash and limited quantities of scratch grain in the litter.

Lot 2 was fed unlimited quantities of dry mash and limited quantities of scratch grain were fed in the hopper.

Lot 3 was fed unlimited quantities of all-mash and no scratch.

Lot 4 was fed unlimited quantities of the ration in compressed pellet form with no scratch grain.

The highest average number of eggs per pullet for the 12 months was made by Lot 2 with an average egg production of 242.7 eggs. This lot was fed the W.S.C. laying mash in the hoppers and a limited amount of scratch grain in hoppers. Lot 1 was second in egg production with an average production of 237.7 eggs. This was the check pen fed on the old W.S.C. laying ration, mash being fed in a hopper, with a limited amount of scratch grain fed in the litter. Lot 4 was third in production with an average egg production of 221.4 eggs. This lot was fed the W.S.C. mash and scratch grain in ground form compressed into pellets. Lot 3 was a few eggs behind

Lot 4 with an average egg production of 218.3 eggs for the year. This pen was fed the W.S.C. laying mash and scratch grain in the form of an all-mash ration.

Cut alfalfa hay was fed the entire year and proved entirely satisfactory as a green food.

The hopper method of feeding scratch grain is more sanitary and gives as good results in production as the previously recommended method of feeding scratch grain in the litter.

With the W.S.C. ration in the pellet form in Lot 4 the hens consumed 4.5 lbs. more feed per pullet per year, than Lot 3, the same ration in all-mash form, producing an average of only three more eggs per hen per year than the all-mash pen.

Protein Requirements for Growing Chicks. (J. S. Carver, L. W. Cassel, and Thomas E. Aspinall). Three lots of chicks were grown on three different levels of protein for a period of forty weeks. Lot 14, on the ration containing 18.12 per cent protein, gave correspondingly more rapid growth the first six weeks than Lot 13 with 15.01 per cent protein, and Lot 12, with 11.9 per cent protein. Advantage of growth was held by each lot until the pullets reached the age of 28 weeks when at that time both Lot 12 and Lot 13 attained the body weight of the high protein lot, No. 14. With the three protein levels studied, the protein efficiency was about the same, while the feed efficiency increased as the protein levels increased when measured by the gain per gram of protein and feed consumed.

Synthetic Rations. (J. S. Carver and Thomas E. Aspinall). In this study, observations were made over an eight-months' period on seven synthetic rations, in an attempt to discover a more satisfactory synthetic ration than has yet been developed. It was observed that feed consumption and growth could be greatly increased by the granulation of the feed by moistening and heating. Five per cent of wheat germ oil was inadequate to entirely prevent paralysis.

There are two obstacles to be overcome before a satisfactory synthetic ration for chicks can be perfected. The food consumption of the birds must be increased and a means of preventing leg weakness of unknown origin must be found.

Poultry Housing. (J. S. Carver, in cooperation with the Western Washington Experiment Station, Puyallup). No definite conclusions were reached at the end of the first year's work. This experiment will be continued another year with special reference to the various ventilating systems and air movements in the several pens. A study of the causes of wet floors is to be included.

DIVISION OF VETERINARY SCIENCE

J. W. Kalkus in Charge

Abortion in Cattle. (J. W. Kalkus and C. E. Sawyer). This project was started in 1923 when the agglutination test for abortion infection was conducted on the Holstein herd at the Western Washington Experiment Station. About 50 per cent of the herd reacted to the test and the herd was segregated into a positive group and a negative group, on the basis of this test.

At present there are four cows which react to the agglutination test in the positive group. Three of these were inoculated with virulent abortus organisms through the teat canal. The other cow reacts as a result of natural infection. This cow was in the negative herd until February 1930 when her serum became positive to the agglutination test. She was immediately transferred to the positive herd, but to date she has not aborted. This is the second cow in the negative herd to become positive to the test during the seven years which the negative herd has been maintained on the same premises with the positive herd.

On August 25, 1928, heifer No. 123 was placed in the positive herd as a contact. She has produced two full time calves and her blood serum has remained negative to the agglutination test for abortion during the two years in contact with the animals in the positive herd.

The three artificially infected cows in the positive herd received a large intravenous injection of acriflavine during the fall of 1927. A detailed report of this treatment was given in Bulletin No. 222 of this station. The sera from these cows continue to give positive reaction on the agglutination test for contagious abortion. This fact is sufficient evidence to draw the conclusion that acriflavine had no effect on the agglutinability of the sera of these animals.

It is planned to dispose of the positive animals in the near future and maintain only the negative herd at this station.

Red Water in Cattle (Cystic Haematuria). (J. W. Kalkus and C. E. Sawyer.) In 1917 S. Hadwen reported a series of experiments which he had conducted in British Columbia to prove that oxalic acid in plants grown on acid soil was the cause of red water. Experiments to duplicate some work of a similar nature were started by one of the writers (Kalkus) in 1924. These experiments in feeding oxalic acid to heifers in an attempt to produce red water, were completed in 1929, and results which were negative were reported in Bulletin No. 237 of this station.

On June 28, 1929, experiments in feeding calcium oxalate to two Holstein heifers were started. Heifer No. 140 was 10 months of age and heifer No. 141 was nine and one-half months of age when placed in this experiment. During the first 15 days each heifer was fed 10 grams of calcium oxalate daily in a gelatin capsule. The dose was then increased to 20 grams daily. Calcium oxalate was not fed from November 16, 1929 to January 10, 1930. The feeding of 20 grams was resumed on heifer No. 141 on January 10, 1930, and increased to 30 grams daily on February 12, 1930.

Heifer No. 140 contracted "wooden tongue" actinomycosis, which became so far advanced that it practically prevented eating, and she became badly emaciated. She was killed and autopsied December 23, 1929. Careful examination of the mucus membrane of the urinary bladder revealed no lesions of red water. This heifer received a total of 1870 grams of calcium oxalate in 101 doses.

Heifer No. 142 has been fed 8540 grams of calcium oxalate in 334 doses to date (September 1, 1930). She is in excellent physical condition and has shown no indication of red water.

ADAMS BRANCH EXPERIMENT STATION

H. W. Wanser in Charge

General Conditions. The season of 1930 was the driest and most adverse in the history of the station. It was the second unusually dry year in succession and on many farms near the station, particularly north and west of it, which usually have been considered in good territory the first absolute crop failure since the land had been brought under cultivation was experienced. The general crop yields in the county were about one-fourth what they had been in the good season two years previous.

The rainfall for the crop year September 1, 1929 to August 31, 1930 was 4.80 inches or 61 per cent of normal. It was the second successive year with the rainfall under six inches whereas the rainfall for the two preceding years had been nearly twice that much. During the growing season March to June inclusive, the rainfall amounted to 2.01 inches or 83 per cent of average. Only 58 per cent of it came in rains of sufficient quantity to wet the seed bed through, or to affect the soil moisture around the plant roots. As a result of the unusually dry winter season there was very little "run off" of moisture at the time of the spring thaw. The available moisture in the summer fallowed soil at the beginning of the crop growing season amounted to only 2.10 inches or about one-half the usual amount. Field yields of spring wheat were about 2.7 bushels per acre for each inch of available soil moisture and effective rainfall.

Varietal Experiments With Cereals. (H. M. Wanser). The varietal experiments in 1930 included sowings in replicated one-fortieth acre plats of 28 varieties of winter wheat, 33 varieties of spring wheat, four varieties each of rye and spring barley and three of oats. Smaller plats in which newer varieties and selections were sown included eight winter wheats and ten spring wheats. A few varieties and about 240 selections mostly from three Baart hybrids were grown in rod rows.

All the fall sowings were made in a dry seed bed and the wheat did not come through the winter with a stand. The winter ryes, however, survived with a thin stand and the yield for Dakold, the best one, was 5.3 bushels compared with 4.3 bushels for Baart spring wheat in adjacent plats.

The varietal trials with spring wheat were sown on three dates and the rainfall during the growing season was so distributed that the average yield for the third date was six-tenths of a bushel better than for the earlier dates which is in contrast to usual experience. Talimka and Koola had the highest average yields with 6.2 bushels. Over a period of years, however, Baart still holds first place by four per cent and the average yield for the 14 crops since the station was established is 12.5 bushels.

In the unreplicated rod row trials three-fourths of the selections from the Baart x Redit hybrid material, the original selection of which had been quite smut free on the main station, showed varying degrees of smut infection. A few quite resistant selections were obtained, however, which equaled or exceeded Baart in yield and gave promise of an improved variety. High resistance to smut was shown in the selections from Hope but only one row showed any promise from the yield viewpoint. Additional selections have been made from the best rows of the Baart x Redit hybrid material in the effort to replace the susceptibility of Baart with smut resistance.

In the Baart x Onas hybrid material where the object has been to increase the upstanding characteristic of Baart after ripening and while still waiting for harvest most of the selections have shown segregating morphological characteristics and several more generations will be required before progress can be measured. Some physiological work probably will be necessary before completion of this project as the upstanding characteristics of the plant after ripening seem to be associated with the length of season in which a plant can remain in the tillering stage and form brace roots without a sacrifice in grain yield and thus take the greatest advantage of delayed spring rains. In many varieties prolonged tillering ability is accompanied by too late maturity and low yield.

In the 40 lots of seed grown to determine the causes of red mixture in Baart all but one contained small percentages of red kernels at harvest. The percentages were small and might be due to error in sorting the seed so the experiment will be continued another season before drawing definite conclusion.

Cultural Experiments with Cereals. (H. M. Wanser). Sowings of winter wheat again were made with a deep furrow drill, but because the soil was dry the usual failure to get a stand with this type of drill when improbable with others was again experienced. After many observations the conclusion has been reached that the moisture which makes it possible to get a stand of winter wheat in the drier sections nearly always comes from timely precipitation.

Sowings of spring wheat also were made with the deep furrow drill, and no advantages were apparent under favorable seed bed conditions. It was quite evident, however, that the use of this type of drill aided in the control of soil drifting which was unusually prevalent in the very dry season. Also better work could be done with this type of drill where the summer fallow had been left with an uneven "trashy" surface.

Tillage and Soil Moisture Problems. (H. M. Wanser). This project was continued according to outlines in previous reports. One-half of each tillage variation is sown to winter wheat and the other half to spring wheat. During the fallow season more weeds usually start on the spring wheat area than on the winter wheat area and some variation such as disked, duckfooted, late plowed and uncultivated (weeds hoed) are poorer than others in weed control. During the first part of the 1929 fallow season the few additional weeds on the spring wheat halves of these tillage variations caused much more moisture to be lost from them than from the winter wheat halves. The slight moisture advantage, varying from three-tenths to one inch and the conditions associated with its cause carried over into the crop year of 1930 and increased the yields of spring wheat (reseeded winter wheat) on the winter wheat half. It was most noticeable on the late plowing where an advantage of seven-tenths inch in moisture increased the yield 2.9 bushels. In many fields over the county which had been in winter wheat two years ago a similar superiority in yield was shown over adjacent fields which had been in spring wheat.

More detail was planned for the measurement of the spring "run off" part of this project but the dry winter nearly prevented any measurements being made. Only .65 inches of precipitation occurred during the frozen period and the one afternoon's "run off" from the stubble area equaled .004 inches. There was no "run off" from the plowed or mulched area. The "run off" waters carried .04 per cent of

their weight in soil. Even though the unmulched or stubble area lost more water by "run off", measurement of the moist soil blanket either by six inch cores to the depth of moisture penetration or by the usual methods of soil sampling showed the stubble area to be 43 per cent better than the mulched area in conserving the winter's precipitation.

Minor Projects and Miscellaneous. (H. M. Wanser). In the study of Forage Problems a start was made to determine the soil binding and sod forming characteristics of some grasses for dry land conditions or for reclamation of abandoned areas. Seed lots of several native grasses were gathered.

In the organic residue series protein determinations of the two preceding crops indicated that moisture rather than available nitrates was one of the limiting factors for the 1929 crop whereas available nitrates had a controlling influence on the 1928 crop. Nitrogen and carbon determinations made on soil samples taken before and after an eight year period with four applications of organic residues did not indicate appreciable influence on the organic matter content of the soil. The most consistent trend indicated continued loss of the original nitrogen content. In the nitrogen fertilizer plots available soil nitrates varied by 300 per cent but yields were uninfluenced showing moisture was the chief limiting factor in 1930 and that fertilizer cannot replace or substitute for the slight moisture advantage gained by the fallow period in dry seasons.

The outlying cereal nurseries which have been conducted in northern Lincoln County were terminated this fall and in cooperation with the Office of Cereal Crops and Diseases, the U. S. Department of Agriculture, a larger one was started in a new location. With the assistance of the local county agent a Field Day was held in June. There was a large attendance and the features of the station were explained.

IRRIGATION BRANCH EXPERIMENT STATION

H. P. Singleton in Charge

General Conditions. Climatic conditions in the irrigated districts for the growing season of 1930 were unusual in that the winter was the most severe since 1919. The minimum temperature at the station was 19.5° below zero but at other locations in the Lower Yakima Valley, temperatures as low as 31° below zero were reported. There were 13 days during January on which the temperature was zero or lower.

Winter injury of fruit trees was very pronounced in the Lower Valley. A survey of the extent and nature of tree injuries was made and is included under Horticulture.

A heavy frost on May 7, at which time the temperature dropped to 26°, caused a large amount of damage to the fruit crop in a few scattered sections of the Lower Valley. The apple crop at the station was completely destroyed. The last frost also injured the alfalfa crop to some extent and the first cutting was lighter than usual. However, very favorable growing weather throughout the remainder of the year caused an increase in the second and third cuttings which resulted in a total yield slightly above average.

The frost-free period was from May 25 to October 9, a total of 137 days. The maximum temperature was 103°. Temperatures as high as 100° or above were recorded on two days only. Total rainfall from October 1, 1929 to October 1, 1930 was 4.64 inches. The supply of irrigation water was practically normal. The station received its allotment of three acre-feet. Since part of the experimental work requires more than the allowance the amount of water for the remainder of the station is less and additional water could have been used to good advantage.

Livestock. Livestock play an important role on irrigated farms and the station program includes dairy cattle, sheep, hogs and poultry. The livestock are used for pasture and feeding investigations and to consume the hay, silage and grain which are produced on the station. Farm products are thereby sold in a more concentrated form and the use of the manure goes a long way toward maintaining the fertility of the soil on the station.

The dairy herd consists of about 25 purebred and grade cows and 20 heifers. Rigid culling, by the use of cow testing records, is practiced. The sheep flock contains approximately 100 grade Hampshire ewes. Between 12 and 16 purebred Duroc Jersey sows are kept. Two litters are farrowed annually. Part of the pigs are sold for breeding purposes but most of them are sold as fat hogs. A poultry flock of about 500 White Leghorn hens is maintained.

Forage Crops. (H. P. Singleton). Investigations with alfalfa varieties were continued. Yields have been obtained from some of the varieties over a period of 10 years. Average yields over this entire period give Northern Grown Common an advantage of .55 tons per acre over Grimm. During a three-year trial the Northern Grown Common also proved superior to unacclimated common strains. Ladak, a new winter-hardy variety, yielded approximately the same as the Northern Common in a three-year average. However, it is not likely

to replace Northern Common to any appreciable extent because it has shown no superior quality to the Common, and seed is not readily available.

Pasture studies were continued on the plots which were established in 1928. A small amount of winter injury to Ladino Clover and the late frosts in the spring held back both the Ladino Clover and mixed grasses to such an extent that the carrying capacity was reduced on both plots. Considerable difficulty was encountered in keeping down weeds on the continuous Sweet Clover plot. The use of Sweet Clover pasture requires the use of some form of rotation for best results.

Second year Biennial White Sweet Clover was not injured by the severe winter or late frosts and had a carrying capacity more than 100 per cent greater than Ladino and the mixed grasses.

All pasture data were secured by actually pasturing the various crops. Sheep and dairy cattle in high production were used in the pasture work.

Cereals and Corn. (H. P. Singleton). Results with cereals for the years 1922 to 1929 inclusive were published in June, 1930. Since winter cereals are used only to a very limited extent under irrigation and yields have not been promising, the plot work with these cereals has been discontinued. Yields of the spring cereals were in accord with those previously published. Wheat gave higher yields in pounds per acre than either barley or oats. Jenkin was again the leading variety with Dicklow about three bushels per acre less. White Russian dropped to fifth place, being outyielded by Federation and Prolific.

Barley and oat varieties in the order of their average yield are Trebi, Blue and Beldi Barley, and Markton, Victory and Banner Oats.

Corn varieties and strains grown this year included two early varieties, five varieties from middle western corn states, and nine local strains of Yellow Dent. The local strains were secured from some of the most successful corn growers in the Yakima Valley.

Yields reported are on the basis of No. 1 shelled corn with a moisture content of 12 per cent. The early varieties, Thayer Yellow and Windus White, produced 59.8 and 67.2 bushels respectively. Yields for the mid-western seed corn ranged from 75 to 85.9 bushels per acre. Reid Yellow was the highest yielding variety. Yields for the local strains varied from 71.8 to 82.2 bushels per acre. The yields this year place Reid Yellow slightly above the best local strains in an eight-year average. However, the fact that good strains of local corn mature earlier than Reid Yellow makes them the more desirable strains.

Soils. (H. P. Singleton). The third cycle in the three-year rotation of potatoes, corn and wheat on the nitrogen fertilizer experiment was completed. These plots receive an annual application of fertilizer and continue to show very pronounced results. Jenkin wheat was grown on the plots this year. Yields varied from 15 bushels per acre on the straw plot to 61.3 bushels per acre on the plot receiving an annual application of manure. The average yield of the check plots was 20.3 bushels. All nitrogen fertilizers, both organic and inorganic increased the yield. The greatest increase for an inorganic fertilizer was about 100 per cent over the check plots, while all organic fertilizers including horse manure, sheep manure, fish meal, and alfalfa hay gave increases of 120 per cent. Alfalfa hay applied at the rate of three tons per acre increased the yield from 20.3 to 44.7 bushels per acre. This emphasizes the possibility of maintaining nitrogen in orchard soils by the use of a legume cover crop, especially if no hay is removed.

In 1925 three additional plots were added to the series. Phosphorus and potash are applied singly on two of them and the other is used as a check. Results to date show an increase of about 20 per cent from the use of phosphorus but potash has no influence on crop yields.

This year nine more plots were added to the series for the purpose of studying the effect of nitrogen, phosphorus, and potash in combination, also that of nitrogen when applied with straw. Yields this year were in proportion to the amount of nitrogen applied. Two tons of straw per acre when applied with 130 pounds of actual nitrogen did not greatly depress the yield under that of plots receiving nitrogen without straw.

A cooperative fertilizer experiment with potatoes was carried on with W. B. Meyers at his ranch near Harrah. The fertilizers were furnished by him and were applied under the station supervision. All yield data were taken by the station. Grading was done by the District Horticultural Inspector of Yakima. The soil is much heavier than that of the station and has been farmed for a shorter time. The experiment was conducted on a field which also produced potatoes in 1928 and 1929.

Manure, composted straw and commercial fertilizers were used in this experiment. With the exception of two complete fertilizers put out by fertilizer companies, the various mixtures used supplied nitrogen in the form of ammonium sulphate, phosphorus as superphosphate and potash as potassium chloride. The two complete fertilizers used were 3-10-10 and 3-10-7. In all cases the increase in yield was almost in proportion to the amount of nitrogen applied. Increases ran as high as 75 per cent on plots which received 130 pounds of actual nitro-

gen per acre. Phosphorus and potash together produced no increase in yield but phosphorus with nitrogen may have caused a slight increase. This, however, was less than the field differences in the check plots. The fertilizers only slightly influenced the grade of potatoes. No plot in the series had less than 77.5 per cent U. S. No. 1 potatoes and no plot had more than 1.6 per cent culls and decay. The average percentage of U. S. No. 1 potatoes on the check plots was 78.1 while the average for the five plots receiving more than 60 pounds of actual nitrogen per acre was 83.1 per cent, with no plot going less than 82.1 per cent.

Orchard Irrigation. (L. L. Claypool). An irrigation project was started this year on the apple orchard. It includes two treatments in the clean-cultivated portion of the orchard and three treatments duplicated in the cover-crop portion. Trees in the 12-hour cover-cropped plots show severe drought injury in some cases. Trees in the 12-hour clean-cultivated plots, and in the 24 and 36-hour cover-cropped plots appear to be in good condition. The alfalfa cover crop is heavier as the amount of water applied is increased. As the apple crop was destroyed by frost, no data on yield were available. Red spider injury on Delicious and Winesap trees is much more severe on the clean-cultivated trees than on those in cover crop.

Pruning. (L. L. Claypool). The pruning systems, minimum, medium, and maximum, were continued as before on Romes and Winesaps. The size of the trees range in the order of the pruning with the minimum pruned trees being of the largest size.

Plum Variety Orchard. (L. L. Claypool). Twenty-four plum varieties including the principal commercial sorts grown on the Pacific Coast were planted. Studies regarding their adaptability to the Yakima Valley will be made.

Cherry Orchard. (L. L. Claypool). A small orchard of Bing cherry trees was planted for future use in experimental work, and to help round out the orchard program of the station.

Orchard Fertilizer Studies. (L. L. Claypool). Preliminary studies on yield and growth of D'Anjou pear trees were made this year previous to the application of fertilizers. This work is a cooperative experiment being carried on at Grandview in the orchard of Mr. F. A. Norton. Although the orchard was apparently very uniform, tremendous differences were found in the yield of individual trees.

Applications of various combinations of nitrogen, phosphorus, and potassium are to be made the first time during the 1930-31 dormant season. Records are being taken on fruit bud count, set, yield, and size of fruit, and on girth, terminal growth, and spur count of the tree.

Cover Crop Studies. (L. L. Claypool). Cover crops were grown again under $\frac{3}{4}$ shade, $\frac{1}{2}$ shade, and in full sunlight. The order in height of growth was Hubam, Biennial White Sweet Clover, Biennial Yellow Sweet Clover, Alfalfa, Hairy Vetch, Alsike Clover and Red Clover.

Two series of plots of alfalfa and Biennial White Sweet Clover were established for nitrogen and water requirement studies.

Winter Injury. (L. L. Claypool). Minimum temperatures ranged from -18°F. to -31°F. in the fruit growing districts of the Yakima Valley. The lowest temperatures were recorded in the Kennewick district and the highest temperatures in the districts west and north of Yakima. Due to the snow cover all of the injury in the Yakima Valley was above ground.

The injury was most severe in the lowlands where lowest temperatures were recorded, and became progressively less in the highlands and up the Valley from Kennewick. Orchards in poor soil or with poor drainage were most severely injured.

The south and south-west sides of the trees were injured more severely than other portions. The degree and type of injury beginning with the species and their varieties listed in the order of their hardiness are:

Plums—no injury recorded.

Apples—no apparent injury until fruit reached fair size. Many creased fruits in districts not touched by spring frosts.

Pears—some flower cluster injury. Creasing of fruits. D'Anjou, Winter Nelis, Bartlett, Bosc.

Apricots—young trees more severely injured than young cherry trees, but old trees damaged less than old cherry trees. Injury to flower buds and twigs. Moorepark, Tilton.

English Walnut—twig, branch and catkin injury.

Cherries—no blossom injury. Young trees scarcely damaged. Old trees have severe leaf-bud, twig and branch injury. Upper branches damaged more than lower branches. Sour varieties, Governor Wood, Tartarian, Lambert, Bing, Royal Ann.

Peaches—some orchards completely killed. Twig and blossom injury. Rochester, Hale and Elberta.

Most of the injured species made marked recovery by the end of the 1930 growing season. However, old cherry trees which had passed through the severe winters of 1909 and 1919 show no recovery and in many cases are in worse condition than earlier in the season.

Cultural Practices on Potatoes. (L. L. Claypool). The irrigation plots again emphasized the necessity of keeping the soil continually moist to obtain the highest total yields and the greatest quantity of No. 1 potatoes.

The plots receiving the least water had half the total yield of those receiving the greatest quantity but only 20 per cent as many U. S. No. 1 potatoes. Other plots were intermediate between these two.

Six to 12-inch spacing of hills gave higher yields and better quality potatoes than 18 to 24-inch spacing. All hills were thinned to one plant per hill.

Where hills were spaced 12 inches apart two and three plants per hill gave a greater yield of No. 1 potatoes than either one or four plants per hill.

The results are in accord with those of previous years.

Potato Fertilization. (L. L. Claypool). Applications of nitrogen, phosphorus and potassium, alone and in various combinations were made again as in 1929 and compared with three check plots and one manure plot. The yields on all plots receiving nitrogen in the organic and inorganic form were higher than yields on other plots, but lower than corresponding yields in 1929. No definite response was obtained from either phosphorus or potash. The yield on each plot was closely correlated to the height of plants.

Certified Seed Trials. (L. L. Claypool). Samples of certified potato seed from Washington, Oregon and Montana, planted by the tuber unit method, again showed superiority over seed one year removed from certification. Each year this advantage has been maintained.

Lettuce Fertilization. (L. L. Claypool). Two series of plots using nitrogen, phosphorus and potassium alone and in various combinations were started this year with the fall crop of lettuce and compared with check plots and manure plots. Seed was planted August 12 which is within the limits of planting time in the Lower Valley. At the normal harvest time the plants were several weeks behind those in the Pasco Districts. Planting will be done in late July in 1931.

Asparagus. (L. L. Claypool). There was no difference in yield or earliness of spear production from rows where cutting had been stopped the previous season at 10-day intervals from April 20 to May 30.

Water Measurement. (C. C. Wright). The total amount of irrigation water delivered to the Experiment Station farm was measured through the three farm turnouts. There were 641 acre-feet of water delivered. This serves an area of 225 acres, hence the average acre-

feet per acre delivered to this land was 2.84 acre-feet. It might be significant to mention that with duty of water, the strictest economy must be practiced in order to get even a fair irrigation of the various crops throughout the season. Water was also measured to five separate fields on the station farm and to various series of experimental plots which were growing different crops. The average application in regular farm practice to these five fields was 7.1 acre-inches per acre. The applications ranged from 4.2 acre-inches to 10.9 acre-inches. A number of measurements were made to determine the conveyance losses in wooden flumes and ditches. The average loss this year was 22 per cent. Surface run-off measurements were made from a tract on the east side of the station farm consisting of 56 acres. This amounted to 17½ per cent of the water delivered to this area.

Use of Metal Flume and Pipe. (C. C. Wright). It was estimated that there were about 500 miles of wooden farm flumes in the lower Yakima Valley, and since the water losses from these flumes are rather high, efforts have been made during the last two or three years to find a suitable substitute for these flumes. In cooperation with some of the manufacturing concerns in the state a metal flume was designed which, it is believed, will answer this purpose. A line of this farm distribution metal flume was installed on the station and also a short line of metal pipe. Both pipe and flume are equipped with small distribution gates for delivering the water to the corrugation furrows. The first cost of this material is slightly higher than the ordinary wooden flume now in use but the total cost over a period of years is less for the metal. In addition to this the metal carriers seem to have other advantages such as better conveyance of water and less danger of damage by fire. Metal flumes also are easier to keep clean and free from moss and other trash than wooden flumes.

Irrigation Experiments with Crops. (C. C. Wright). Different quantities of water were applied to six plots of alfalfa. These quantities ranged from two acre-feet per acre to five acre-feet per acre measured at the field. The yield of hay was somewhat in proportion to the water applied. The plot receiving five acre-feet produced a total of 7.7 tons of hay per acre, and the plot receiving two acre-feet, 5.2 tons per acre. Different quantities of water were also applied to 10 duplicate plots of potatoes and nine duplicate plots of corn. The various applications to the potato plots ranged from nine to 72 acre-inches. The yield of potatoes did not correspond to the water applications. The yield on the plot receiving nine acre-inches was 7.13 tons per acre, and on the plot receiving 72 acre-inches, 7.34 tons per acre. The corn plots received from 12 to 30 acre-inches. On the plots which received 12 acre-inches the yield was 23.1 bushels per acre, and on the plot receiving 30 acre-inches of water, 23.6 bushels per acre. A series

of these corn plots also received water in intervals of 10, 20, and 30 days. The plot receiving a 24-hour run of water every 20 days for four irrigations yielded 67.8 bushels, the highest of any plot in the series.

Various amounts of water also were applied to wheat ranging from 6 inches to 24 inches. The yield of wheat corresponded somewhat to the amount of water applied except that the plots receiving 12 inches or more yielded approximately the same. There is some evidence that other factors limit the yield after 12 to 18 acre-inches of water are applied.

A serious need for more accurate methods of measuring water is apparent. It is believed that the results obtained may be somewhat confusing on account of possible inaccuracies in making water measurements on the various plots. Evidence of this showed up in the yields of alfalfa from small basin plots, 30 feet square, where a better opportunity for careful water measurement was possible. The amount of water applied to these basins was two, three and four acre-feet and the yields were 2.8, 4.5, and 5.4 tons per acre, respectively. In the fall irrigation experiment on alfalfa the yield on the plot which was fall irrigated was equal to and slightly more than on the plots which received spring irrigation in accordance with customary practice.

Soil Moisture Studies. (C. C. Wright). Studies on water relations of the soil were continued by taking soil samples for moisture determinations on the basin plots referred to above. No increase in water-holding capacity of the soil due to continued cropping or the application of barnyard manure was noted. The average amount of moisture retained in the soil over winter was approximately 2.5 inches per foot down to a depth of six feet.

Sprinkler Irrigation of Orchards. (C. C. Wright). A cooperative experiment was conducted in the Wenatchee Valley on the irrigation of orchards by the sprinkler method. The amount of water applied to the various plots and the resulting soil moisture situation was measured and determined by this station. The results obtained indicated that with a total of two to three acre-feet of water applied, only the surface two or three feet are moistened. There was some evidence also that there would be a cumulative depletion of the moisture from the lower layers of soil if this method of irrigation were to be continued.

Supplementary to this experimental work in the Wenatchee Valley a circular concrete basin, 50 feet in diameter, was constructed at the Prosser Station. Here experiments to determine the atmospheric loss of water from various types of sprinklers will be conducted in 1931.

Groundwater and Drainage. (C. C. Wright). Groundwater studies on areas adjacent to two large open drains in District No. 9, Yakima County, were continued. This is the third year of such observations in this district. The results indicated that the drains are serviceable only as a prevention of increased water-logging and not as a relief in lowering the groundwater table. Numerous samples were also gathered from drains in alkali areas and the total salts determined by means of the electrolytic bridge. These samples of drainage water ordinarily carried between three and four hundred parts per million total salts. This would seem to indicate that very little movement of water through these salty lands was taking place.

CRANBERRY BRANCH STATION

D. J. Crowley in Charge

General Conditions. The 1930 cranberry crop both in Washington and in Oregon was very small. There was a series of very favorable years from 1923 to 1927 inclusive but the last two years have been very unfavorable. For about three weeks in January and February this year the bogs were covered with a sleet which formed on the vines. This occurred at a time when no snow had fallen and few of the bogs had enough water to be of any protection. When the sleet melted off the vines no injury was noted, but later in the spring when growth started, the results of the winter injury were readily seen. Many of the uprights in some of the more badly injured bogs turned brown and shed their leaves. The injury was by no means confined to the cranberry vines as many of the native evergreen shrubs, such as the Salal, were completely defoliated. The frost of May 9th and 10th which caused injury to crops all over the Northwest also hit the cranberries when they were in a tender stage. These conditions prevailed even as far south as Coos County in Oregon and up into Grays Harbor, Washington. All the frosted bogs, however, have recovered and have a good set of fruit buds for the coming year.

Dormant Sprays. The first experimental sprays for insect control in 1930 were directed against the eggs of the cranberry fireworm and also against the Oyster-shell and Putnam scales. These sprays were chiefly oils with a viscosity of from 100 to 140. They were applied at strengths of from 2½ to 4%. When sufficient spray was applied to reach the scale infested stems, good control was obtained in all cases, but unfortunately, practically all fruit buds were killed by the dormant oil sprays. A 3% oil applied at the rate of 500 gallons per acre caused no injury, but the same oil, at the same strength, caused serious injury when 800 gallons per acre were applied. This oil spray injury was noticeable until late in the summer. Dormant oil sprays

cannot be safely used for scale control on heavy cranberry vines, as apparently the oil film builds up to the point where it is toxic to the plant by the time that enough spray is applied to reach the scale infested stems. The percentage kill of the fireworm eggs in the plots sprayed with the dormant oil was between 50 and 60.

Summer Oils. The following oils were used either in combination with nicotine sulfate, free nicotine or pyrethrum:

Sum-r-oil—Hood River Spray Company.

Medol—Balfour Guthrie Company.

Medol light—Balfour Guthrie Company.

Petrotine 60—Associated Oil Company.

Petrotine 70—Associated Oil Company.

Orthol K medium—California Spray Chemical Company.

RL106c—Shell Oil Company.

RL106d—Shell Oil Company.

RL293a—Shell Oil Company.

RL293b—Shell Oil Company.

RL294 —Shell Oil Company.

The results of this season's work with oil sprays check very closely with those previously obtained. Oils with a viscosity of about 65 gave uniformly good results. Their ovacidal value was greater than lighter oils and there was no injury to the crop when not more than two oil sprays were applied in succession. When heavier oils were used some injury resulted. Two oil sprays can be safely applied prior to blossoming. These should be in combination with nicotine sulphate, free nicotine, pyrethrum extracts or with lead arsenate. The lead-oil combination, however, is not nearly as effective as the others for controlling the cranberry fireworm. A higher percentage kill of both the Oyster-shell and Putnam scale in the crawler stage was obtained with the pyrethrum oil combination than with the nicotine oil spray. This difference was so noticeable that one could pick out the pyrethrum oil plots by their more thrifty appearance when compared with those receiving other treatments.

Nicotine sulphate plus soap or oil is more effective than pyrethrum against the blackhead fireworms when the latter become webbed up in the leaves. Many of the fireworm larvae can be killed by a one to 400 nicotine spray even in the webbed condition provided the temperature is 70°F. or higher. Most of the first brood sprays, however, are applied when the temperature is 60°F. or under and at that temperature pyrethrum sprays are more satisfactory than the nicotine. No variation in the efficiency of the pyrethrum has been noted because of high or low temperatures. It apparently kills entirely by contact.

Field tests were carried on this year using pyrethrum throughout the season, and the results secured were satisfactory. Growers who have used it were equally well pleased.

Penetrol. Penetrol, a sulphonated oxidized petroleum product was tested here this season both in laboratory and field tests on most of the cranberry insect pests. Combined with nicotine, the latter can be used at a dilution of one to 1000 for the blackhead fireworm. Penetrol also is very satisfactory as a carrier for pyrethrum insecticides. Unfortunately, however, it cannot be used for more than two sprays in succession, as, like oil sprays, it causes injury. Its use, except in the early part of the season, is not advocated until further tests have been made. For the first two sprays it can be used to advantage at the rate of three pints to 100 gallons of water, with either nicotine sulphate, free nicotine or pyrethrum. Penethrum, a combination of pyrethrum and Penetrol, was found to be effective against the fireworm at a dilution of one gallon to 300 gallons of water. It should be used only in the early part of the season, however.

Evergreen. Evergreen, an alcoholic extract of pyrethrum, was used in field tests throughout the season and was found to be a safe spray at all stages of the crop. Occasionally, a late hatch of the fireworm makes it necessary to apply a spray when the crop is in full bloom. Evergreen is the safest spray to use at this time, as in our field tests it caused less injury than any of the others.

Imazu. Imazu, another pyrethrum spray, gave good results when used at the rate of one pound to 50 gallons of water. It can be safely used at all stages of the crop.

Uenothron. Uenothron, a highly concentrated pyrethrum soap, was found effective against the cranberry fireworm at one gallon to 800 gallons of water. It is not as convenient to handle in field use, however, as some of the other pyrethrum brands.

Derris Extracts. Neoton, a Derris derivative, was tried again this season, but proved to be no more effective than the less expensive pyrethrum sprays. Rotenone was tried against the fireworm and fruitworm at the rate of three ounces to 100 gallons of water. The results obtained show that it kills both fireworm and fruitworm larvae at this strength and also acts as a repellant to chewing insects for several days after the plants are sprayed with it.

Potassium Fluo-Aluminate. This spray, which is a stomach poison, was applied against the fruitworm in a small test plot. The results obtained were encouraging enough to justify trying it on a larger scale

during the next season. The supply of Rotenone and Potassium Fluoro-Aluminate were obtained through the courtesy of the U. S. D. A. Chemical Laboratory at Wenatchee.

Fruitworm. This insect is a very difficult one to control by sprays. The millers emerge more or less continuously from June to September so that even if a complete kill is made by any spray, a new infestation will occur again in a short time. The present method of control is the use of a contact spray in combination with an ovicide when large numbers of the millers are emerging. Lures and baits of many kinds tested this season fail to attract the fruitworm moth. A Frost insect electrocutor with a light and volatile oil bait attracted large numbers of fireworms, but only one or two fruitworms in a three-week test.

Parasitic Control. In the report of the Massachusetts Cranberry Experiment Station for 1915, Dr. H. J. Franklin reported that *Trichogramma minuta* Riley was an important parasite of the fruitworm in Cape Cod. This insect which parasitizes the eggs of a number of economic insect pests was available this season in commercial numbers. They are raised artificially by Dr. A. W. Morrill at the Orange County Insectory at Anaheim, California. This station shipped in 25,000 of them and liberated them in the Cranberry Laboratory bog and in a few adjacent ones. Cages were also built where numbers of fruitworm millers were confined. All fruitworm eggs in those cages were parasitized by the *Trichogramma* and parasitized fruitworm eggs were noted in the bogs where the *Trichogramma* were liberated. Further experiments on a larger scale along those lines are planned for the coming season. Fruitworm injury was much lighter this season than in the two previous years, only one bog having a serious infestation. This was a five-acre tract adjacent to a large area that had the crop killed by frost and it is quite probable that the moths came in from the adjacent bog where there was no fruit.

Fertilizer Tests. A five plot test, each plot containing one-tenth of an acre, was carried on this season in cooperation with the Agronomy Division at the State College at Pullman. The plots received the following treatments:

- No. 1 30 pounds Chilean nitrate of soda.
- No. 2 30 pounds super-phosphate plus 30 pounds Chilean nitrate of soda.
- No. 3 Check.
- No. 4 30 pounds nitrate of soda, 60 pounds super-phosphate and 20 pounds potassium sulphate.
- No. 5 20 pounds potassium sulphate, 60 pounds super-phosphate.

While weather conditions practically ruined the crop in those plots, enough berries were available for storage tests, and samples of the soil from each plot were sent to the State College for analysis. Definite results on the value of these fertilizers should be available next season.

The Cranberry Laboratory. The blueberry crop in this bog was a good one, in spite of weather conditions; although there was less than one tenth of an acre with bushes of bearing age, \$50.00 of blueberries were marketed. Fifty new plants from cuttings were added to the plantings, as well as five new varieties obtained from Dr. Frederick V. Coville, U. S. D. A., at Washington, D. C. To date, no insect pests or fungi have caused any injury in the blueberry plot. There will be some acreage planted to blueberries locally during the coming spring, and many requests for information on blueberry growing have been received from practically every county west of the Cascades.

Though weather conditions hit the experimental cranberry bog, as well as all others, 140 boxes of berries were shipped. This is approximately one-third of what the crop would have been had it not been for weather conditions. Three-fourths of an acre was planted this year, which means that there are now slightly over four acres planted. Of this amount nearly three will be in bearing in 1931.

Conclusion. Though unfavorable weather has been encountered for the past two seasons, there is a normal development of new acreage for the coming year. Some growers are planting new ground, and others are changing over from marginal varieties to the McFarlin. The bogs as a whole are in good condition to produce a crop for 1931.

PUBLICATIONS

The following bulletins and scientific papers were published during the year July 1, 1929 to June 30, 1930.

General Bulletins

- 234 The Present Use of Work Time of Farm Homemakers. Arnquist, I. F., and Roberts, E. H. 31 p. July, 1929.
One hundred and thirty-seven records were obtained from farm cooperators, who spent an average of 63 hours a week in work, 53 hours in homemaking tasks, and 10 hours in farm work. The season, type of farm and help received do not materially change the average of 53 hours in homemaking tasks, but the first two factors do affect the time spent in farm work. Very little time saving is shown in individual households where labor saving equipment is used.
- 236 Collar Rot of Apple Trees. Magness, J. R. 19 p. October, 1929.
Symptoms of the trouble, relation of the injury to the soil type, irrigation practices, and other factors; and the treatment of the affected trees to facilitate their recovery are reported.
- 237 Thirty-Ninth Annual Director's Report. 66 p. December, 1929.
This summarizes the work of the Washington Agricultural Experiment Station and expenditures for the fiscal year ended June 30, 1929.
- 238 Economic Aspects of the Washington Fruit Industry. Johnson, Neil W. 72 p. April, 1930.
This is a comprehensive study of the soft fruit crops grown in the Wenatchee and Yakima districts of Washington, including apricots, cherries, peaches and pears. Costs of producing these fruits in each locality were compiled from three year's records, and a comparison made of the relative advantages of each soft fruit.
- 239 Economic Aspects of Apple Production in Washington. Johnson, Neil W. 79 p. April, 1930.
A study embracing a three-year period on the cost of producing apples in the Wenatchee and Yakima districts, together with a study of the financial returns of about 200 representative orchards during the same years.
- 240 The Production of Cereals Under Irrigation. Singleton, H. P. 20 p. June, 1930.
This bulletin gives the results of eight years' work with cereals at the Irrigation Branch Experiment Station at Prosser. Results discussed include varietal trials, time of sowing, seed treatment, rate of sowing and irrigation. The relative value of the different cereals also is shown.
- 243 The Effect of Calcium and Phosphorus Content of Various Soil Series in Western Washington Upon the Calcium and Phosphorus Composition of Oats, Red Clover, and White Clover. Holtz, H. F. 45 p. June, 1930.
This bulletin reports the relationship between the total calcium and total available phosphorus in 17 important soil series in western Washington and the crops grown upon these soils. The data show that the mineral content in the majority of soil series directly influences the composition of the crops; they also show that the mineral content of oats grown in western Washington is lower than that grown east of the Rocky Mountains.
- 33 Application of Stellite to Agricultural Tools. (Engineering Bulletin). Thornton, G. E., and Johnson, C. C. 19 p. March, 1930.
The value of the application of stellite to plow shares is reported. In very dry soil ordinary shares required sharpening at end of each day's run. Shares treated with stellite were in good condition after a run of six 10-hour days without sharpening.

Popular Bulletins

- 146 Washington Chick Rations. Carver, J. S., Buchanan, W. D., and Miller, M. W. 20 p. November, 1929.
A ration developed at the Main Experiment Station is recommended. Complete directions for the feeding of this chick ration are presented in this bulletin.
- 147 The Farm Shop. Smith, L. J., and Garver, H. L. 24 p. June, 1930.
Descriptions of a small and a large farm shop are included. The former was designed for use on a dairy, poultry, or other small farm, the latter on farms where large machinery or tractors are used. Figures on costs of operation of various equipment. Methods of connecting electric motors in the shop, and methods of calculating the size of pulleys for operating different machines are included. A one horse power motor was found sufficiently large for most shops. In many cases a $\frac{1}{2}$ H.P. motor is ample.

Papers Published in Scientific Journals

- 155 Studies of Quality and Maturity of Apples. St. John, J. L., and Morris, O. M., Jour. Agr. Research 39:623-39. October, 1929.
Variation in duplicate samples shows that comparatively large samples should be taken for analysis. Grade should be considered in sampling. The level of sugars and other fractions varies in different years. Sacrose increases during the growing season. Too much significance may previously have been attached to small variations in acid. The alcohol insoluble acid hydrolyzable material shows greater variation than any other fraction. Climatic factors have a decided effect upon quality. Fruit and adjacent foliage should be well exposed to sunshine.
- 156 Biological Values and Supplementary Relations of the Proteins in Alfalfa Hay and in Corn and Sunflower Silage. Sotola, J. Jour. Agr. Research 40:79-96. January, 1930.
Biological values of the proteins in alfalfa hay, corn silage, and sunflower silage were determined. These were found to be 56, 94, and 67 respectively. A combination of one part alfalfa hay and three parts corn silage had a value of 81, while the mathematical mean calculated on the basis of the nitrogen that each contributed to the mixture was 64. This shows a difference of 17, due to the favorable supplementing effect of the two proteins. Similarly, a value of 62 was obtained for the mixture of proteins contained in one part of alfalfa hay and three parts of sunflower silage. The mathematical mean of 58 in comparison shows only a negligible supplementary effect.
- 157 A Study of the Accuracy of the Gutzeit Method for Arsenic. Neller, J. R., Jour. Assoc. Off. Agr. Chem. 12:332. August, 1929.
The effect of various factors upon accuracy was studied. It was concluded that duplicate analyses give sufficiently accurate results. A method of preparing sensitized strips is described and some precautions are listed.
- 158 Thermal Efficiencies of Aluminum Saucepans. Landreth, C., and Hutchinson, R. O., Jour. Home Econ. 21:599-604. August, 1929.
It is shown that heavy aluminum utensils are no more efficient than light weight ware for use with electric stoves. Their greater cost can be justified only on the basis of greater durability.
- 159 Plasticity of Flour-Water Suspensions. St. John, J. L., Cereal Chem. 6: 400-10. September, 1929.
A new method of measuring plasticity of flour-water suspensions was studied. Results on mobility may be closely duplicated. There is a time factor in the mobility of such suspensions. The effect of various factors on mobility was evaluated. Mobility did not change with age of flours. With a number of flours, an increase in plasticity seemed to be related to loaf-volume.

- 161 Cultures and Strains of the Stinking Smut of Wheat. Kienholz, Jess and Heald, F. D., *Phytopathology* 20:495-512. June, 1930.
A study of different methods of growing the two species, *Tilletia levis* and *T. tritici*, in cultures in an attempt to differentiate physiological strains. It was not possible to segregate physiological strains on the basis of cultural characters alone. Field inoculations using pure cultures were unsuccessful.
- 162 The Effect of Plant Maturity on the Biological Value of Alfalfa Proteins. Sotola, J., *Record of Proceedings of Amer. Soc. Anim. Prod.* 24-29. December, 1929.
Results indicate that neither the stage of maturity nor the number of the cutting of alfalfa have an influence upon the biological value of the proteins contained in the different samples of hay fed. The nitrogen of the young plant is just as well utilized as is the nitrogen of the older plant, even though a higher percentage of nitrogen is known to be present in the true protein form in the mature plant. Fifty-four biological values determined with sheep are presented. One-fourth, one-half, and three-fourths to full bloom stages of alfalfa were studied. The average of the total of 54 biological values of alfalfa proteins is presented at 93.5 per cent, which signifies that for every 100 pounds of digestible protein of the alfalfa plant, 63.5 per cent is retained for use in the animal body by fattening lambs.
- Potato Flea-Beetles in Washington, *Epitrix subcrinita* Leconte: *Epitrix cucumeris* Harris. Webster, R. L., and Baker, Wm. W. *Jour. Econ. Entom.* 22:897-900. December, 1929.
Although damage to foliage is often severe, the greatest injury is to the tubers, by reason of the tunneling of the larvae. Late planted fields in general are less damaged than those planted early. The most satisfactory results from insecticide dusts were obtained in using a combination of hydrated lime, finely-ground sulfur and nicotine sulfate, representing an actual nicotine content of two per cent.
- Recent Developments in Combination Sprays for Codling Moth Control. Spuler, Anthony, and Dean, Fred P. *Proc. 25th Annual Meeting Wash. State Hort. Assn.* 57-63. December, 1929.
A summary of field and laboratory tests of mineral-oil and lead arsenate combinations, fish-oil and lead arsenate, and mineral-oil and nicotine sulfate combinations.
- Lessons in This Year's Experience in Codling Moth Control. Spuler, Anthony, *Proc. 25th Annual Meeting, Wash. State Hort. Assn.* 143-144. December, 1929.
- A Plant Disease Mystery Solved. Heald, F. D. *Northwest Science.* 3:123-126. December, 1929.
An account of the discovery of the relation of the curly top virus to tomato yellows.
- Relation of Leaf Area to Size and Quality of Apples and Pears. Magness, J. R., Overley, F. L., and Luce, W. A. *Proc. Wash. State Hort. Assn.* 25: 167-170. December, 1929.
The relation of leaf area to fruit size. Cross pollination tests on D'Anjou pears 1926 to 1928 showed that the best set of fruit occurred at the very tip of the limbs, where the leaf surface was the largest. The tests with Lambert cherries show that four or five leaves per fruit were necessary to produce maximum size fruit. In thinning operation of fruit the leaf area is the most important factor.
- Relation of Codling Moth Combination Sprays to Injury and Residue Removal. Overley, F. L. *Proc. Wash. State Hort. Assn.* 25:89-94. December, 1929.
The effect of the application of summer oils in the spray program on the functioning of leaves, the size and grade of fruit. The size of the fruit on heavily loaded trees is affected when four or more applications of summer oil are used in the spray program.

New Combination Sprays for Codling Moth Control. Spuler, Anthony, and Dean, Fred P. Journ. Econ. Entom. 23:53-61. February, 1930.

The addition of mineral oils to lead arsenate greatly improved its insecticidal value. Adding fish-oil was even more effective. Nicotine-oil combinations were shown to be fully as effective as lead arsenate during the first brood and decidedly more effective in the second brood sprays.

Relation of Leaf Area to Size and Quality of Apples and Pears. Magness, J. R. and Overley, F. L. Proc. Amer. Soc. Hort. Sci. 26:160-162. February, 1930.

The determination of the leaf surface required to synthesize the organic food utilized in the development of apples and pears. A definite correlation was found between number of leaves and size of fruit until at least 30 leaves per fruit were available.

Effect of Fertilizers on Storage Quality of Apples. Magness, J. R. and Overley, F. L. Proc. Amer. Soc. Hort. Sci. 26:180-181. February, 1930.

Two years' results of fertilizer studies on storage qualities of apples. Fruit receiving nitrogen has been somewhat poorer in color, and color has not been improved by adding P_2O_5 and K_2O in addition to the nitrogen. There has been to date no measurable difference in rate of softening due to fertilizer treatment. Though nitrogen fertilized trees showed more physiological breakdown in 1928 due to one very bad tree, the difference between the plots is not statistically significant.

Relation of Oil Spray to Production of Apples in Washington. Overley, F. L. and Spuler, Anthony. Proc. Amer. Soc. Hort. Sci. 26:343-347. February, 1930.

The relation of different sprays and other factors to fruit bud injury and set of fruit and the relationship of various emulsifiers used in the oil sprays and of oil concentration to plant injury. Injury may result if sprays are applied during the critical period (delayed dormant) of bud development. Stable emulsions have proven safer than the quick breaking emulsions.

Relation of Combination Sprays to Spray Residue Problems in Washington. Overley, F. L. Proc. Amer. Soc. Hort. Sci. 26:348-350. February, 1930.

Progress in cleaning spray residue from apples from 1925 to 1929 is reported. Mineral oil and fish oils in combination with lead arsenate and nicotine sulfate in the spray program give much promise in codling moth control, but with present information and washing equipment the spray residue removal is too great a factor to make general recommendations, and special spray recommendations are suggested.

Observations on the Pests and Diseases Peculiar to Sour Cherry. Jones, Leon K. Proc. Wash. State Hort. Assn. 25:212-215. March, 1930.

The various types of injury to sour cherry that may be caused by insects or diseases are discussed. Recommendations for the reduction in injury from these sources are noted.

FINANCIAL STATEMENT
WASHINGTON AGRICULTURAL EXPERIMENT STATION

in account with
the United States Appropriations, 1929-30

Dr.	Hatch	Adams	Purnell
Receipts from the Treasurer of the United States, as per appropriations for the fiscal year ended June 30, 1930, under acts of Congress approved March 2, 1887 (Hatch Fund), March 16, 1906 (Adams Fund), and February 24, 1925 (Purnell Fund)	\$15,000.00	\$15,000.00	\$60,000.00
Cr.			
By salaries 1	\$10,741.23	\$12,530.44	\$42,695.91
Labor 2	2,123.33	1,036.39	7,566.61
Stationery and office supplies 3	38.80	3.25	138.99
Scientific supplies, consumable 4	401.52	585.51	1,070.91
Feeding stuffs 5	—	—	12.45
Sundry supplies 6	75.27	154.78	1,289.21
Fertilizers 7	4.00	—	49.85
Communication service 8	—	2.40	72.18
Travel expenses 9	471.30	347.97	3,062.97
Transportation of things10	—	—	15.96
Publications11	672.40	—	1,620.75
Heat, light, water, and power12	—	—	55.00
Furniture, furnishings, fixtures ..13	1.34	—	174.20
Library14	—	—	1.00
Scientific equipment15	252.30	329.72	1,376.84
Livestock16	—	—	58.00
Tools, machinery, and appliances 17	218.51	9.54	684.17
Buildings and land18	—	—	55.00
Contingent expenses19	—	—	—
Balance20	—	—	—
Total	\$15,000.00	\$15,000.00	\$60,000.00

FINANCIAL STATEMENT
STATE FUNDS EXPENDED ON THE MAIN STATION AND
ALL BRANCH STATIONS

(Excepting Western Washington Station which is operated
independently)

July 1, 1929 to June 30, 1930

Dr.	State Appropriations	Sales	Totals
Balance, June 30, 1929	\$ ———	\$ 2,647.54	\$ 2,647.54
Receipts from other sources than the U. S. for the year ended June 30, 1930	50,147.15	20,209.53	70,356.68
Totals	\$50,147.15	\$22,857.07	\$73,004.22
 Cr.			
Salaries	\$20,619.22	\$ 416.66	\$21,035.88
Labor	17,834.76	4,262.16	22,096.92
Stationery and office supplies	799.46	355.42	1,154.88
Scientific supplies, consumable	754.85	591.05	1,345.90
Feed	459.85	2,162.92	2,622.77
Sundry expenses	869.61	2,349.48	3,219.09
Fertilizers	222.22	———	222.22
Communication service	223.22	72.37	295.59
Travel	2,403.70	1,807.67	4,211.37
Transportation of things	487.24	149.76	637.00
Publications	443.34	898.36	1,341.70
Heat, light and power	1,918.40	302.63	2,221.03
Furniture and fixtures	175.77	351.37	527.14
Library	1,605.98	1,324.23	2,930.21
Scientific equipment	569.82	1,007.87	1,577.69
Livestock	50.00	280.00	330.00
Tools, machinery and appliances	430.53	1,073.54	1,504.07
Buildings and Lands	279.18	1,514.99	1,794.17
Balance, June 30, 1930	———	3,936.59	3,936.59
Totals	\$50,147.15	\$22,857.07	\$73,004.22

FINANCIAL STATEMENT
WESTERN WASHINGTON EXPERIMENT STATION

July 1, 1929 to June 30, 1930

Dr.	State		Totals
	Appropriations	Sales	
Balance, June 30, 1929	\$————	\$17,907.97	\$ 17,907.97
Receipts from other sources than the U. S. for the year ended June 30, 1930	\$54,868.66	28,715.01	83,583.67
Totals	\$54,868.66	\$46,622.98	\$101,491.64
Cr.			
Salaries	\$20,354.71	\$ 6,249.90	\$ 26,604.61
Labor	16,388.12	7,297.30	23,685.42
Stationery and office supplies	————	————	————
Scientific supplies consumable	455.94	225.87	681.81
Feed	10,209.68	3,337.90	13,547.58
Sundry expenses	2,060.74	1,326.92	3,387.66
Fertilizers	————	————	————
Communication service	546.61	302.50	849.11
Travel	1,299.99	746.24	2,046.23
Transportation of things	76.74	58.64	135.38
Publications	30.77	1,872.99	1,903.76
Heat, light and power	603.55	449.63	1,053.18
Furniture and fixtures	138.33	————	138.33
Library	165.82	110.92	276.74
Scientific equipment	————	1,641.99	1,641.99
Livestock	————	————	————
Tools, machinery and appliances	1,156.20	————	1,156.20
Buildings and lands	1,381.46	621.03	2,002.49
Balance, June 30, 1930	————	22,381.15	22,381.15
Totals	\$54,868.66	\$46,622.98	\$101,491.64

TABLE OF CONTENTS

Introduction	5
Changes in Staff	13
Buildings and Land	13
Detailed Reports	13
Division of Agricultural Engineering	14
Division of Agronomy	14
Division of Animal Husbandry	21
Division of Chemistry	23
State Chemist	25
Division of Dairy Husbandry	26
Division of Entomology	30
Division of Farm Management and Agricultural Economics	34
Division of Home Economics	38
Division of Horticulture	40
Division of Plant Pathology	47
Division of Poultry Husbandry	50
Division of Veterinary Science	52
Adams Branch Experiment Station	53
The Irrigation Branch Experiment Station	56
Cranberry Branch Station	65
Publications	70
Financial Statements	74

